Exhibit C

Evaluation of Environmental Contaminants and Health Risks in the Metropolitan Complex

Expert Report

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1 Purpose and Basis

I have examined materials relevant to understanding potential exposures and adverse health risks in the case: Maxus Metropolitan, LLC. versus Travelers Property Casualty Company of America, Case No. 20-cv-00095-FJG (US District Court – Missouri). My review of documents and my evaluation focus on the following: the extent of smoke penetration into the Maxus Metropolitan apartment building complex (Metropolitan) as a result of the structure fire on September 27, 2018 fire; the significance and distribution of fire-related combustion residues determined by sampling and analysis by Maxus; the adequacy of sampling protocols, analyses and interpretations related to combustion residues and mold; whether detected or remaining fire-related combustion residues were likely to cause adverse health effects among building occupants; and whether full remediation or reconstruction of Phases 1-4 buildings was warranted as a result of the risks of adverse health effects associated with fire-related combustion residues determined from the sampling and related analyses. My evaluation is based on the data, reports, and other references cited in this report, including the text, footnotes and list of documents reviewed.

My qualifications are described in the curriculum vitae provided. I am an environmental health scientist and engineer with research and teaching interests in exposure science, risk and health impact assessment, and epidemiology applied to occupational, community and environmental settings. I received a BS in environmental science from Rutgers University, and Masters and PhD in Civil & Environmental Engineering from the Massachusetts Institute of Technology. Previously I taught and conducted research in Massachusetts, Texas, Finland, Austria, Portugal, and elsewhere. Since 1989 I have been at the University of Michigan where I am Professor of Environmental Health Sciences, Professor of Global Public Health, and Professor of Civil and Environmental Engineering. I addition, I am Honorary Professor, Department of Occupational and Environmental Health at the Medical School University of KwaZulu-Natal, Durban, South Africa. At Michigan, I am Center Director of the *National Institute of Occupation Safety and Health supported T42 University of Michigan (UM) Center for Occupational Health and Safety Engineering*, and the *National Institute of Environmental Health Sciences (NIEHS) supported T32 Environmental Toxicology and Epidemiology Program*, and I lead the leader of the Exposure Assessment Core of the NIEHS-supported P30 *Michigan Center on Lifestage Environmental Exposures and Disease*. My research and teaching emphases ambient and indoor air quality, exposure and risk assessment, environmental epidemiology, and air quality modeling. I routinely procure highly competitive federal and other grants and complete research addressing air quality, housing quality, and other environmental health topics. My laboratory specializes in exposure measurements and exposure assessment, including trace organic measurements in biological and environmental samples, and my group conducts a wide range of laboratory and field studies, as well as environmental modeling and statistical analyses. I am committed to conducting impactful research, to developing training and research programs that promote knowledge and capacity in the occupational and environmental health sciences including training at UM, elsewhere in the US, and abroad, and to community engaged research and policy-relevant work. I have published over 220 peer-reviewed journal articles, hundreds of abstracts and reports, of which many are peer-reviewed. I have made numerous scientific presentations on environmental health topics, and served on city, state and national panels on environmental health topics.

In the past 5 years I have given been deposed and given testimony in a case before the Alberta (Canada) Energy Regulator in Applications 1842705, 1851246 and 1851250, Proceeding ID 346, Balshaw Oil Corp. In addition, I been retained in the following cases: Tatjana Blotkevic, Ilya Peysin and Yakov Yarmove v. City of Chicago, No. 2016-CH-02292; Sierra Club v. Union Electric Company d/b/a/ Ameren Missouri, Civil Action No. 14-cv-00408-AGF; Robert and Kerry Ellen Hart vs. Mountain West Farm Bureau Mutual Insurance Company; U.S. District Court Case No. CV 19-08-M-DWM. In the latter three cases, I have not testified or been deposed. During this period, I have also given testimony in public hearings related to permitting and rule-making in environmental matters before the Michigan Department of Environment, Great Lakes and Energy, and before the U.S. Environmental Protection Agency. I am being compensated for this work at a rate of $425 per hour.

2 Chronology

The Metropolitan Apartments are a residential complex constructed of three wood frame slab-on-grade buildings with a parking garage, located in Birmingham, Alabama. The three buildings are referred to as the Phase 1-3 building or the "donut building", the Phase 4-5 building that wraps around the parking structure, and the stand alone Phase 6 building. The complex is bounded by 6th Avenue to the north, 7th Avenue to the south, 30th Street to the east, and 29th Street to the west. Commercial and light industrial businesses are located along 6th Avenue and to the north, with service and retail establishments along 7th Avenue and to the west. An architectural plan showing the building "phases" is shown in Figure 1. Figure 2 shows the floor plan and unit numbers. Other floors have similar numbering of units other than the first digit indicating the level.

On the night of September 27, 2018, at 0:37, the local fire department was dispatched to 2900 7th Ave South to respond to a two alarm fire that occurred in the detached (except for connecting bridge) southeast, stand-alone building (referenced as the Phase 6 building), which sustained a catastrophic fire and burned completely. The building burned very quickly, on the order of 2 hours.[1] The fire was extinguished by 6:00 am.[2] The earlier phase of the fire, well before daybreak, was the most intense based on the incident report and television news coverage.[3] Much of the firefighting equipment was cleared by approximately 8:00 in the morning, although some equipment remained on site until 14:30.[4]

At the time of the fire, approximately 17 units on the 4th floor were occupied, in the Phase 1-3 Buildings, based on the Rent Charges/Payments Ledger. Phases 4 and5 were unfinished. , e

On June 11, 2019, Maxus counsel stated their intention to evict all tenants from the Metropolitan, and the building complex was vacated by June 17, 2019 (263 days after the fire). At this time, 96 units in Phase 1-3 Buildings were occupied.

In October, 2019, Bear Claw Construction Management, LLC, initiated the removal of sheet rock from Phase 1-3 buildings, essentially deconstructing the building to framing.

Maxus contracted with Forensic Building Science, Inc. (FBS) to conduct inspections and collect environmental samples at the Metropolitan. A total of 15 visits from Jan. 9, 2019 through August 27, 2020 conducted for this purpose were identified. Most of these visits occurred in 2020.

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1 Security video taken at or near 2930 7th Ave South throughout the fire, immediately south of the Phase 6 building. This camera points approximately north and directly at the Phase 6 building.

2 Birmingham Real-Time News. Massive 2-alarm fire destroys Lakeview apartments, law office; Birmingham firefighter hurt. https://www.al.com/news/birmingham/2018/09/massive_2-alarm_blaze_destroys.html

3 TV Channel 13, WVTM, DRONE VIDEO: Massive fire destroys 4-story apartment building in Birmingham's Lakeview Districthttps://www.wvtm13.com/article/drone-video-massive-fire-destroys-4story-apartment-building-in-birminghams-lakeview-district/23498813

4 Birmingham Fire & Rescue Service Incident Report 2018-0050328

Figure 1. Architectural plan with corresponding area classifications. From Irmiter exhibit 47.

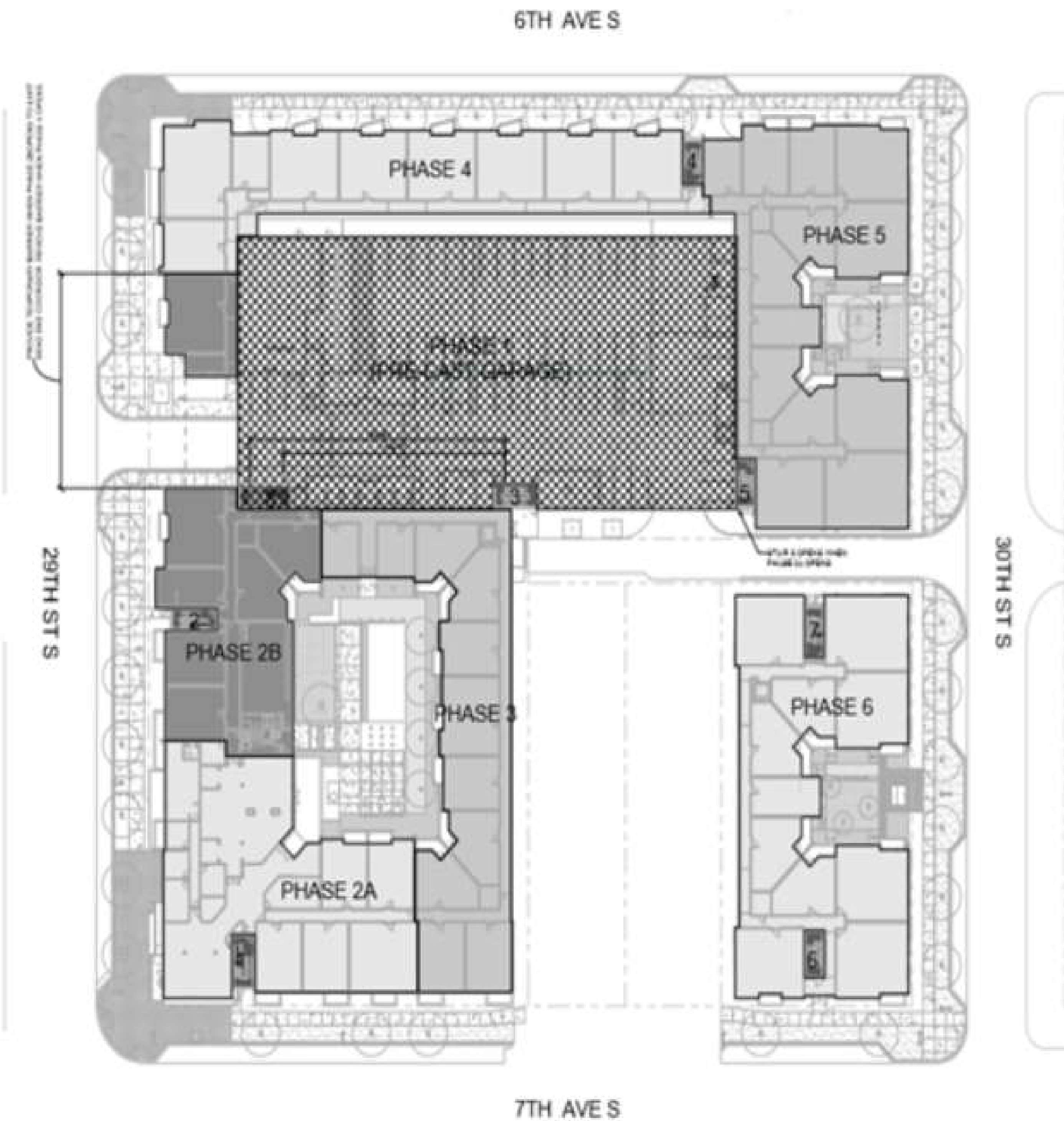
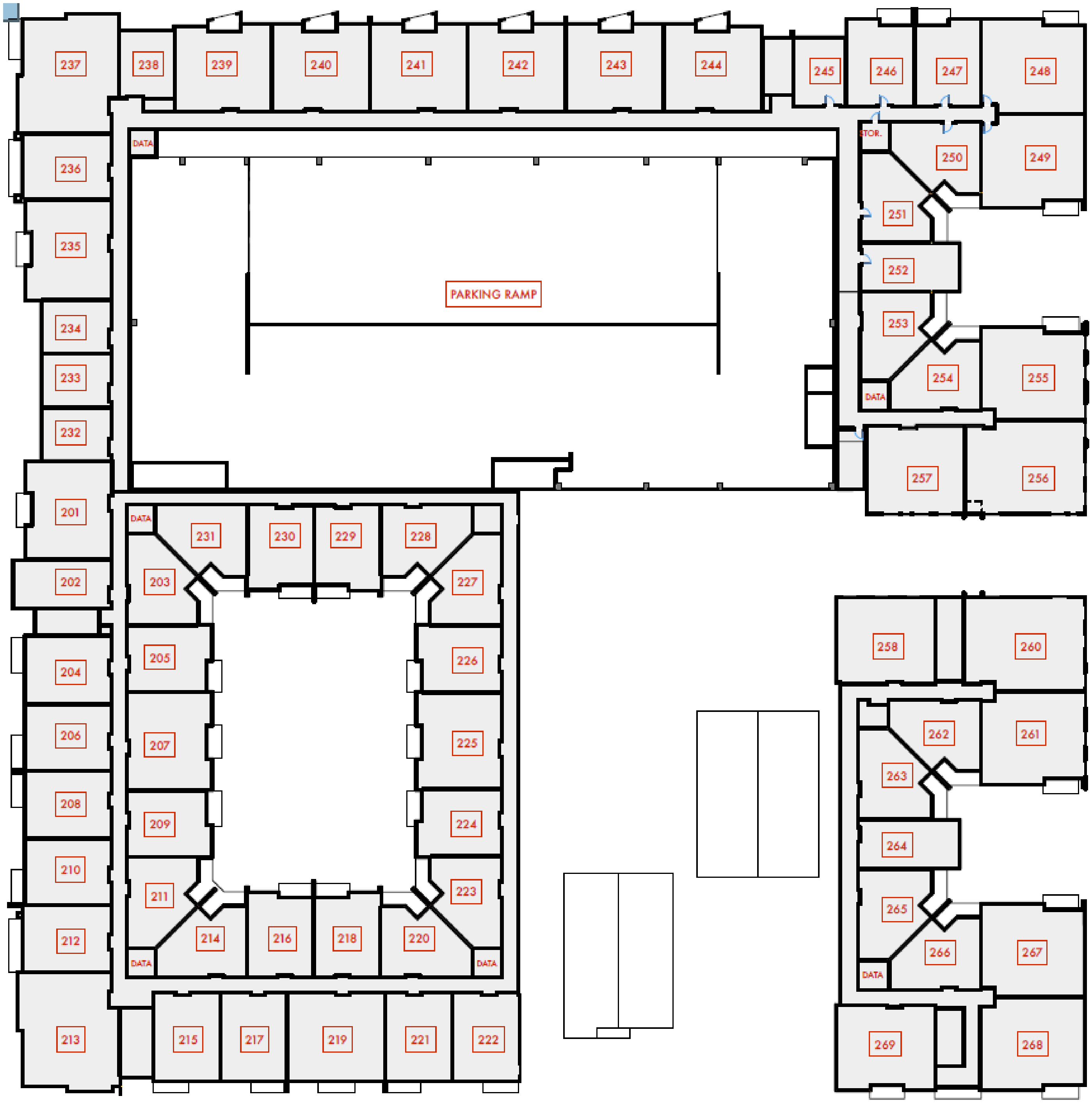


Figure 2. Floor plan for 2nd floor of the Metropolitan. From R. Schroeder.



3 Impact of fire-related emissions on indoor environmental quality and health

Structure fires and their smoke plumes can affect indoor environments and indoor environmental quality (IEQ) through several mechanisms and in several phases. The fire at the Phase 6 structure was external to the Phase 1-5 buildings. This section provides background on the emissions, transport and fate of fire-related pollutants, called *combustion residues* in this report, which might occur from the emissions of the Phase 6 structure fire that migrated into the Phase 1-5 buildings.[5] Additional background regarding smoke transport and infiltration in Section 4.

Fire-related pollutants can be emitted and found in a building through one or several of mechanisms or phases defined and discussed below with reference to the Metropolitan Phase 6 building fire.

3.1 Direct exposure

In the initial or active phase of the fire, emissions of gaseous and particulate pollutants from a fire may enter occupied portions and interstitial spaces of the building (e.g., attic, wall cavities), a result of normal *air exchange, air infiltration*, and pollutant *penetration* through the building envelope, which can cause direct exposure to building inhabitants if present. Following the fire, airborne pollutant concentrations in the building will decline rapidly as normal air change rates flush out airborne pollutants, typically in a few hours. Other pollutant loss mechanisms, e.g., settling, deposition and reaction, also occur and are discussed below. Pollutants of most concern for direct exposure include volatile organic compounds (VOCs), gases (e.g., carbon monoxide), and particulate matter. Direct exposure to fire-related contaminants is normally avoided by evacuation of building residents. Direct exposure to fire-related contaminants is not an issue at the Metropolitan.

3.2 Settling and deposition

Particulate and some gaseous/vapor phase pollutants from a fire may *settle or deposit* on building surfaces, both exposed surfaces and hidden surfaces and in building cavities. In wild land fires, exterior surfaces of a structure generally sustain the most direct impact of wildfire residues;[6] similar deposition and settling processes will occur for nearby buildings exposed to smoke from structure fires. A fraction of particulate and some gaseous/vapor phase pollutants may penetrate the building envelope or enter the HVAC system. Some pollutants may *absorb* into porous materials (e.g., foam, fabrics, carpets, filters, insulation). Surface cleaning of exposed surfaces, material removal, and other remediation activities are expected to reduce or eliminate much of this contamination. The presence of settled or deposited char, soot and ash on interior building surfaces and building cavities is the rationale for many of statements regarding the condition of the Metropolitan (Sections 4 and 5).

3.3 Off-gassing

Settled, deposited and/or absorbed solid-phase pollutants may later produce gas-phase emissions, known as *off-gassing* or the *sink/source* effect. Emissions from off-gassing can include parent compounds or reaction products. Both will be emitted in the vapor phase, and these emissions may later condense or absorb and coagulate to

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5 There appears to be some confusion in the record regarding the origin and identification of combustion residues. While the fire was a structure fire, any fire-related combustion residues found in the Phase 1 – 5 buildings resulted from the entry or penetration of particles through the building envelope and into the building; these residues were not generated internally in Phase 1-5 buildings. In this regard, combustion residues are similar to a wild land fire: pollutants were emitted from the nearby source; released into the atmosphere; underwent cooling and physical and chemical changes; and then exposed nearby buildings to "aged" combustion products, including soot, ash and char. In the case of the Metropolitan, however, these emissions arose from a structure fire.

6 AIHA, 2018 Daniel Baxter, Alice Delia, Susan Evans, Brad Kovar. AIHA Technical Guide For Wildfire Impact Assessments. A Guide for the Occupational and Environmental Health and Safety Professional. American Industrial Hygiene Association, April 2018.

become particulate-bound and re-settle or re-deposit on other surfaces. Sink/source processes can apply to some VOCs and semi-volatile organic compounds (SVOCs). The significance of sink/source processes depends on the pollutant, substrate, and environmental conditions. Generally, off gassing rates and indoor concentrations decline over time as the pollutant is depleted or degraded; higher ventilation rates and higher temperatures will increase the rate of decline, and rapid declines are expected for VOCs and many SVOCs including polycyclic aromatic hydrocarbons (PAHs) (Section 7.3.3). Months or potentially years after a contamination event, sink/source effects may be significant only for certain compounds, e.g., very low volatility and persistent chemicals, and only under certain conditions, e.g., disturbances (Section 7.3) .

3.4 Entrainment

The physical disturbance of previously settled and deposited pollutants that have accumulated on surfaces or dust may be *entrained* and *re-entrained* into air. Disturbances can include vibration, movement, sweeping, and high velocity air flows (as in an air duct). Cleaning of surfaces will greatly minimize the potential for entrainment of fire-related combustion residues. In building cavities, disturbances that cause entrainment of previously deposited or settled combustion residues are very unlikely with the exception of building repairs on specific surfaces or aggressive sampling techniques (Section 7.3.2). Outdoors, burnt materials and soil contamination immediately after the fire can contain friable materials that can be entrained by winds; this material would normally be removed or covered soon after a fire, and thus these emissions would be short-lived.

3.5 Heat-related emissions

Heating of building materials and furnishings may produce emissions that affect indoor pollutant levels. High and prolonged temperatures can cause or increase emissions by: increasing off-gassing rates of components present in building materials and furnishings (e.g., from oils and resins in wood and construction materials); initiating reactions forming airborne emissions (e.g., charring and burning); and deteriorating or destroying the integrity of materials that subsequently leak and/or release contaminants (e.g., melting of plastics and caulks and bursting of capacitors in electronics). There is minimal if any documentation in occupied spaces in Phases 1-3 or elsewhere of heat-related emissions or related concerns.

3.6 Remediation

Remediation activities, which can include physical disturbances (e.g., sweeping and vacuuming) and use of chemicals (e.g., cleaners, deodorants, sterilizers, disinfectants), may affect the indoor environment. Typically, remediation activities produce the highest emissions and concentrations during the remediation. The likelihood of significant emissions or impacts due to typical remediation practices conducted months or years earlier is typically minimal.

3.7 Summary

This section has reviewed mechanisms pertinent to fire-related emissions and chemical exposures in buildings that can cause health risks. A primary concern at the Metropolitan is that the contamination of building surfaces and materials by fire-related combustion residues will cause adverse health effects among occupants due to carcinogenic substances such as PAHs. As detailed below, no evidence supports this conjecture.

4 Smoke transport and infiltration

Outdoor smoke from a structure fire or other source can enter a building if two conditions are present: (1) the *building exterior must be exposed to smoke and high concentrations of fire-related pollutants*, particularly at air entry locations and for prolonged periods; and (2) *air infiltration and particle penetration of smoke and fire-related pollutants enter through the building envelope and into the building*.[7] These conditions – the *exposure* and *completed pathway* – depend on the fire and building configuration, local and prevailing meteorology, pressure differences, pollutant type, and other factors.

4.1 Winds during the fire and plume transport

Meteorological data measured at two airports near the Metropolitan are summarized in Table 1. Two airports are near the Metropolitan: the Birmingham Airport is 5.5 NNE of the Metropolitan, and the Bessemer Airport is 15.9 miles SSW. These airports span the Metropolitan location, as shown in Figure 3. Data from the two airports substantially agree during the fire period and thus are representative.

From midnight to 5:59 am on 27 September 2018, winds were light or classified as calm, (no wind detected); the average wind speed was 1.7 to 2.1 mph (depending on the airport), and the wind direction was from the SSE and S. From 5:59 am to 12:00 pm, wind speed increased slightly (average of 4.3 to 6.9 mph) and the direction remained from the SSE and S. These are very light to light winds. *Sheltering* effects from nearby buildings would tend to reduce the wind speed in Birmingham from the measurements at the airports. Overall, meteorological conditions at the time of the fire and immediately after were calm, very light or light winds from the SSE and S.

Given the calm, very light and light winds during the fire, the fire would produce a heated and buoyant plume that would rise vertically and be transported upward and primarily to the north and the north-northwest. Figure 4 shows the orientation of the Metropolitan building complex. The general plume direction and vertical rise of the plume is corroborated by the placement of the firefighting equipment on the 7th Avenue South midblock location[8] and videos taken from appropriate perspectives.[9] Based on prevailing winds, the plume direction would direct the plume away from Phase 1-3. Phase 5 and a portion of Phase 4 are in the downwind direction of the plume; however, the vertical movement of the plume, called *updraft* or *plume rise*, is the dominant transport mechanism given the calm, very light and light winds during the fire and the sheltered location of the Metropolitan.

Wind speeds immediately after the fire are too low to entrain material into the air.

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7 *Infiltration* normally refers to air leakage through unintentional openings in the exterior envelope of a building, driven by wind, indoor-outdoor temperature difference and equipment operation. *Particle penetration* refers to the entry of particles into a building via leaks in the building enclosure or envelope. These terms have been used interchangeably by FBS but they are not the same.

8 Birmingham Fire & Rescue Service, Incident Report, 2018-0050328. The incident commander designated the 29th Street location as the alpha side of the structure, and reported heavy black smoke on alpha (front: 29th Street) and bravo (left: 6th Ave). No smoke was reported on the delta side (right side: 30th Street).

9 Video footage from a drone provides a good perspective to show the plume rise, as captured by WTVM, Channel 13, "Drone video of Lakeview fire" at https://www.wvtm13.com/article/birmingham-firefighters-battling-massive-commercial-fire-in-lakeview-district/23483089, accessed Nov. 1, 2020.

Table 1. Meteorological observations at Birmingham and Bessemer airports for Sept. 27, 2018 from 12:00 am to 2:30 pm, as available.[10] Horizontal lines separate observations into midnight to 5:59 am and 6:00 am to 11:59 periods. Horizontal lines show averaging periods. Averages shown at bottom of table.

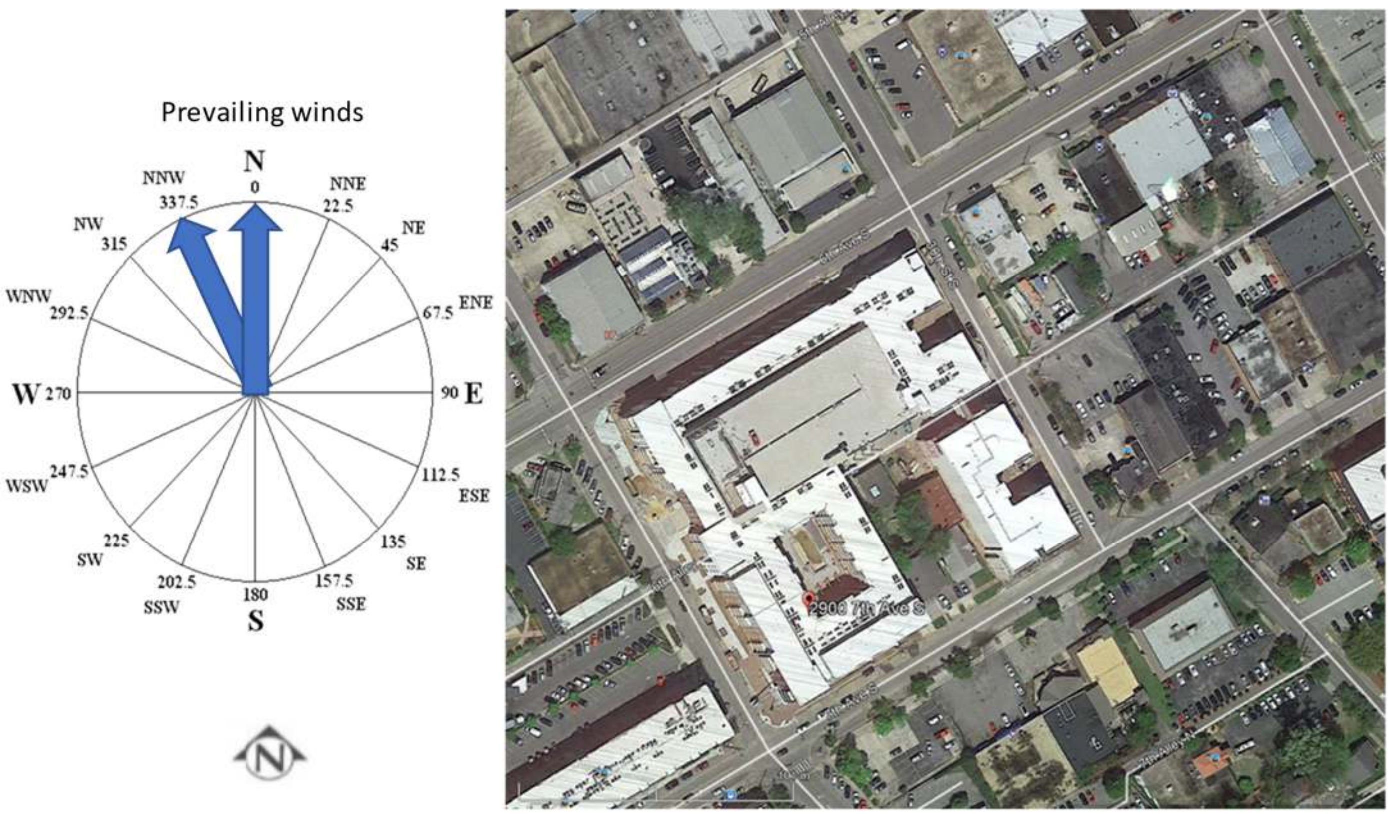
Birmingham Airport (1)										Birmingham Airport (2)				Bessemer Airport			
Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure	Precip.	Condition	Time	Wind Dir (o)	Condition	Wind speed (mph)	Time	Wind Dir (o)	Condition	Wind speed (mph)
12:38 AM	71 F	69 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:38:00		Calm	0.0	0:56:00		Calm	0.0
12:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:51:00		Calm	0.0	1:56:00		Calm	0.0
1:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	0:53:00			3.4	2:24:00		Calm	0.0
2:53 AM	72 F	70 F	93 %	SSE	3 mph	0 mph	29.34 in	0.0 in	Cloudy	0:59:00		Calm	0.0	2:35:00	220		3.4
3:38 AM	71 F	70 F	96 %	SSE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	1:53:00				2:46:00	240		3.4
3:53 AM	71 F	70 F	96 %	SSE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	2:53:00		Calm	0.0	2:50:00		Calm	0.0
4:35 AM	71 F	70 F	96 %	SSE	5 mph	0 mph	29.33 in	0.0 in	Cloudy	3:38:00	160		3.4	2:56:00		Calm	0.0
4:53 AM	71 F	71 F	100 %	S	3 mph	0 mph	29.33 in	0.0 in	Cloudy	3:51:00	150		3.4	3:27:00		Calm	0.0
5:04 AM	71 F	71 F	100 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	3:53:00	150		3.4	3:47:00		Calm	0.0
5:53 AM	72 F	70 F	93 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	4:35:00	160		3.4	3:56:00		Calm	0.0
6:53 AM	72 F	70 F	93 %	SE	3 mph	0 mph	29.33 in	0.0 in	Cloudy	4:53:00	150		4.7	4:33:00	150		4.7
7:53 AM	72 F	71 F	97 %	CALM	0 mph	0 mph	29.34 in	0.0 in	Cloudy	5:04:00	170		3.4	4:37:00	150		3.4
8:53 AM	73 F	71 F	93 %	S	7 mph	0 mph	29.34 in	0.0 in	Cloudy	5:53:00		Calm	0.0	4:52:00	160		3.4
9:00 AM	73 F	71 F	93 %	S	6 mph	0 mph	29.34 in	0.0 in	Light Rain	6:53:00		Calm	0.0	4:56:00		Calm	0.0
9:09 AM	73 F	71 F	93 %	S	7 mph	0 mph	29.35 in	0.0 in	Cloudy	7:53:00	140		3.4	5:09:00	160		3.4
9:43 AM	74 F	72 F	93 %	S	6 mph	0 mph	29.35 in	0.1 in	Light Rain	8:51:00		Calm	0.0	5:56:00	150		5.8
9:53 AM	74 F	72 F	93 %	S	7 mph	0 mph	29.35 in	0.1 in	Light Rain	8:53:00	180		6.9	6:14:00	140		4.7
10:00 AM	74 F	71 F	91 %	S	7 mph	0 mph	29.35 in	0.0 in	Cloudy	9:00:00	180		6.9	6:50:00	160		4.7
10:09 AM	74 F	72 F	93 %	S	9 mph	0 mph	29.35 in	0.0 in	Cloudy	9:09:00	180		5.8	6:56:00	150		3.4
10:42 AM	75 F	72 F	90 %	S	10 mph	0 mph	29.34 in	0.0 in	Cloudy	9:43:00	180		6.9	7:56:00	160		5.8
10:53 AM	75 F	72 F	90 %	SSW	8 mph	0 mph	29.34 in	0.0 in	Mostly Cloudy	9:53:00	180		5.8	8:56:00	180		4.7
10:56 AM	76 F	73 F	91 %	SSW	7 mph	0 mph	29.34 in	0.0 in	Mostly Cloudy	10:00:00	170		6.9	9:56:00	180		5.8
11:53 AM	79 F	72 F	79 %	SSW	13 mph	17 mph	29.33 in	0.0 in	Cloudy	10:09:00	180		6.9	10:33:00	200		6.9
12:53 PM	77 F	72 F	84 %	SW	9 mph	0 mph	29.31 in	0.0 in	Light Rain	10:42:00	180		9.2	10:56:00	210		6.9
1:23 PM	77 F	73 F	88 %	W	7 mph	0 mph	29.29 in	0.0 in	Rain	10:53:00	190		10.3	11:56:00			4.7
1:31 PM	75 F	73 F	94 %	WNW	8 mph	0 mph	29.28 in	0.1 in	Heavy Rain	10:56:00	200		8.1	12:08:00			6.9
1:41 PM	74 F	73 F	97 %	WNW	9 mph	0 mph	29.28 in	0.4 in	Rain	11:53:00	200		6.9	12:56:00	180		8.1
1:53 PM	76 F	74 F	94 %	VAR	5 mph	0 mph	29.27 in	0.4 in	Cloudy	12:53:00	200		12.8	13:56:00	190		9.2
2:01 PM	76 F	72 F	87 %	SSW	3 mph	0 mph	29.27 in	0.0 in	Mostly Cloudy	13:23:00	220		9.2	14:21:00	210		8.1
2:35 PM	76 F	73 F	91 %	CALM	0 mph	0 mph	29.27 in	0.0 in	Heavy Rain	13:31:00	260		6.9	14:51:00	240		6.9
Aveage from 0:00 to 5:59 am					1.7						157		2.1		176		1.7
Average from 6:00 to 11:59 am					6.9						180		6.0		173		5.3

[10] (1) From Weather underground https://www.wunderground.com/history/daily/us/al/birmingham/KBHM/date/2018-9-27

(2) From National Center for Environmental Information, https://www.ncei.noaa.gov/access/search/data-search/global-hourly?stations=72050799999&stations=72228013876 Wind speed converted to mph.

Figure 3. Map showing locations of airports. The Metropolitan and fire site was located in central Birmingham, between the two airports. Modified from NOAA.

Figure 4. Left: Compass rose showing downwind direction of prevailing S and SSE winds during the fire period; Right: Google Earth photo of the Metropolitan complex, dated 4/2018, with the correct orientation with respect to the compass rose.



4.1.1 Plume dispersion

The dispersion of smoke and plumes is well understood, and many types of pollution sources are competently modeled to estimate exposures that may result.[11] In brief, the flow, randomness and turbulence of atmosphere wind field produces a degree of mixing and dispersion, with additional small scale *micrometeorological* affects due to flow over and around obstacles (like buildings) and from other effects. This means that while the dominant or average direction of a plume from a fire can be determined from the prevailing wind field, there is always a degree of vertical and lateral spread of the plume due to gusts, eddies and turbulent dispersion. In the case of the Metropolitan, the dominant direction was vertical and to the N and NNW. Dispersion would occur that would broaden or spread the plume, with the resultant direction likely to include portions of the upper floors of Phases 4 and 5. As shown in Section 7, this is consistent with the areas where most fire-related combustion residues were identified with high likelihood.

In certain cases, especially large and open fires can produce changes (perturbations) of the wind field. One such effect is the formation of a *convergence zone*. In general, heated and buoyant gases above the fire combustion zone cause the plume to ascend and *updraft*. In certain large forest fires, plume-driven fires (occurring with light winds) can draw in air near the ground surface, forming a short-lived and localized convergence zone. The radial inbound air flows in such zones have velocities that are much reduced from updraft velocities.[12] While unlikely, if such a convergence zone formed at the Metropolitan fire site, then in buildings other than the burning Phase 6 structure, building sides facing the fire (*near side*) would experience a slight drop in air pressure that could reduce infiltration, while building sides opposite the fire (*far side*) would experience a slight increase in pressure that could increase infiltration, however, the building far side would be expected to have considerably less exposure to the smoke plume. In any event, the ground level air velocities from such a hypothetical convergence zone resulting from the structure fire would be too low to cause significant wind-induced infiltration and particle penetration through the building envelope. Overall, there is no evidence for prolonged and significant convergence zone or other fire-induced perturbation of the wind field that would be likely to significantly increase infiltration and particle penetration into the Phase 1-3 and Phase 4-5 buildings.[13]

4.1.2 Incorrect interpretation of meteorology conditions

Contrary and misleading meteorological information was presented by FBS, who reported the maximum wind speed as 25 mph, the direction from the northwest, and winds as "sustained".[14] A brief but intense thunderstorm

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[11] Much of my work focuses on atmospheric dispersion modeling of pollutants, including stationary and mobile sources in order to understand exposures and the potential for health effects. Please see CV.

[12] There are numerous field campaigns and modeling studies regarding air flows pertaining to forest fires. For example:

Lareau, Neil P., Craig B. Clements. The Mean and Turbulent Properties of a Wildfire Convective Plume, *Journal of Applied Meteorology and Climatology,* 56, 8, pp. 2289-2299, 2017

Charland, AM, C. B. Clements. Kinematic structure of a wildland fire plume observed by Doppler lidar. *Journal of Geophysical Research: Atmospheres*, 118, 3200–3212, 2013.

[13] If winds were high and "sustained" as erroneously stated by FBS, then the discussion fire-induced convergence zones and wind field modification would not apply and thus be irrelevant. In contrast, in the Expert Report on p. 21, FBS asserts: "In my opinion, winds generated by this fire, not winds in the surrounding area, created the perfect condition for distribution of microscopic fire particulate and combustion byproducts that are harmful. These winds and the heat from the fire created the mechanism for the building pressurization to occur."

[14] FBS, Fire Damage Report for The Metropolitan, 2700 7th Avenue South, Birmingham, AL 35233. June 5, 2019. (Exhibit 47). This report (and the expert report) makes a number of speculative, undocumented, sometimes contrary and sometimes irrelevant speculations, including the following:

occurred at the Birmingham airport from about 2:40 pm to 3:15 pm September 27, 2018, which produced a very brief period of high winds and a brief reversal of the prevailing direction. However, this has no bearing during the night-time fire period when winds were calm, very light, or light and from the SSE and S.

FBS inappropriately quoted an interview of a scientist formerly at NCAR discussing *coupled fire atmosphere dynamics* that can result in perturbation of the wind field purported to apply to the Metropolitan fire.[15] The cited paper from this scientist, from 1996,[16] uses numerical modeling to simulate line-type forest fires under primarily light winds in a modeling application mainly intended to test several hypotheses under simplified and hypothetical scenarios. While an interesting and relatively early paper on coupled fire-atmosphere dynamics, this paper is largely irrelevant to understanding wind patterns related to the Metropolitan fire: it simulates line fires from 420 to 1500 m long (0.25 mile to nearly a mile) of eucalyptus trees that are uniformly distributed across a landscape, not a structure fire in a heterogeneous urban setting; there are substantial differences in burn rates, geometries and other factors between the simulated line fire and the actual structure fire that do not scale down; important elements of the model are considered crude (e.g., fire model, radiation model); the model does not include effects of the forest canopy on drag, and thus does not simulate the effects of nearby buildings on sheltering and drag; the model spatial resolution (finest was 40 m) could not represent features of a structure fire like the Phase 6 fire (the building dimension, approximately 55 x 26 m, would be represented with a single pixel) and extrapolations are fallacious; and the paper's simulations have not been validated with real field data.

The FBS expert report made additional speculations and misleading statements regarding infiltration and local conditions.[17]

On p. 3: "In our opinion, based on the type of construction of the building, the methods used to fight the fire, and the sustained winds the night of the fire, smoke, soot, and particulate matter penetrated all aspects of the unfinished buildings and much of the finished building areas. Emphasis added.

Text on p. 4 notes: "As part of our investigation FBS conducted weather research into wind speeds and wind direction during the event. According to that research sustained high winds blowing in a northwest direction occurred. In our opinion, this could have resulted in winds carrying soot, water, and particulates onto, and throughout, all remaining structures interiors by way of the open bypasses throughout the complex and HVAC equipment which was operating in the occupied spaces." Emphasis added.

On p. 20 of the FBS Expert Report, FBS asserts both "positive and negative pressure" in the building.

On p. 55: "The analysis by Carlson is consistent with the spread of combustion byproducts from this fire and a building that underwent a sudden and dramatic pressurization caused by the heat and winds generated by the fire."

On p. 14 and 15, it is asserted that the fire caused "fire whirls" and "weather modifications".

[15] FBS, 2020, ibid. p. 15 describes an indirect reference to Clark, see below, and asserts: "In my opinion, this fire was large enough to effectively create its own weather pattern in the form of circulating high winds forcing Phases 1-4 to pressurize and become engulfed in smoke. While the fire was not large enough to create a "meteorological event" like some forest fires and volcanoes it did extend well above the structure" …. "the fire was large enough to create its own weather pattern."

[16] Clark, Terry L.; Mary Ann Jenkins; Janice Coen; David Packham A Coupled Atmosphere Fire Model: Convective Feedback on Fire-Line Dynamics, *Journal of Applied Meteorology*, 35, 6 1996, pp. 875-901.

[17] FBS, Expert Report, Oct. 5, 2020. For example, on p. 12: "turbulent winds created by the fire and the heat from the fire caused the pressurization of the building to change and pushed black smoke, and combustion byproducts from the fire into Phases 1-5." Emphasis added.

4.2 Infiltration of smoke and fire-related pollutants

The second necessary condition for smoke entry is the entry of outside air into the building. Modern building like the Metropolitan have engineered systems that limit air and moisture entry, e.g., the Metropolitan used the ZIP System sheathing designed to form a tight and continuous barrier, on top of oriented strand board (OSB), which is also highly impermeable. Air and smoke from a fire and other ambient air pollutants can enter a building by crossing through the building envelope, including these barriers, driven by several mechanisms: *mechanical air change* due to fans drawing in outside air; *natural ventilation* through open windows and doors; and *infiltration* though gaps and leaks in the building envelope. The housing units at the Metropolitan did not utilize HVAC systems with mechanical air exchange. "Infiltration" has been claimed as the means by which fire-related combustion residues entered Phase 1-5 buildings.

Infiltration will only occur if there is a *pressure difference* across the building envelope, specifically, higher pressure outdoors and lower pressure indoors. A pressure difference can arise from several factors: (1) effects of winds; (2) indoor-outdoor temperature differences, called the *stack effect*; and (3) if certain multiple fan heating, ventilation and air conditioning (HVAC) systems are operating but incorrectly balanced (configured). The latter is not relevant given the recirculating HVAC systems present in the housing units at the Metropolitan. There are many ways to measure or estimate both infiltration rates and inter-zonal flows that could lead to infiltration and migration of air between interior spaces; [18] no such measurements at the Metropolitan were conducted.

Given that prevailing wind conditions were calm, very light or light winds, as discussed in Section 4.1 and Table 1, wind-induced pressure differences in the Metropolitan buildings would have been negligible, thus wind-induced infiltration would be negligible.

Given that the outdoor temperature was 71-72 ºF for most of the fire (Table 1), very close to indoor temperatures expected in the housing units, the indoor-outdoor temperature difference is negligible. The similar indoor-outdoor temperatures mean that there is no or minimal temperature-induced pressure difference or stack effect, thus temperature induced infiltration would be negligible.

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[18] My group (including collaborations with US EPA and others) conducts research addressing infiltration, air change rates, and interzonal transport in buildings and pollutant migration, including a variety of health related applications and advances in measurement and assessment approaches. Examples of peer-reviewed publications include:

Liuliu Du, Stuart Batterman, Christopher Godwin, Jo-Yu Chin, Edith Parker, Michael Breen, Wilma Brakefield, Thomas Robins, Toby Lewis "Air change and interzonal flows in residences, and the need for multi-zone models for exposure and health analyses, *International Journal of Environmental Research and Public Health*, 2012 9(12): 4639-4661.

Breen, Michael S., Janet M. Burke, Stuart A. Batterman, Alan F. Vette, Gary A. Norris, Christopher Godwin, Carry W. Croghan, Bradley D. Schultz, Thomas C. Long. Modeling Spatial and Temporal Variability of Residential Air Exchange Rates for the Near-Road Exposures and Effects of Urban Air Pollutants Study (NEXUS). *International Journal of Environmental Research and Public Health*, *11*(11), 11481-11504, 2014;

Batterman, S., Luilui Du, Christopher Godwin, Zachary Rowe, Jo-Yu Chin, "Air exchange rates and migration of VOCs in basements and residences," *Indoor Air*, 25, 6, 598-609, 2015.

Carrilho, João Dias, Mário Mateus, Stuart Batterman, Manuel Gameiro da Silva. "Air Exchange Rates from Atmospheric CO_2 Daily Cycle, *Energy and Buildings*, 92, 188-194, 2015. doi:10.1016/j.enbuild.2015.01.062.

Batterman, S., "Review and Extension of CO_2-Based Methods to Determine Ventilation Rates with Application to School Classrooms," *International Journal of Environmental and Public Health Research,* 2017, 14, 145; doi:10.3390/ijerph14020145

Batterman, S., Feng-Chiao Su, Andrew Wald, Floyd Watkins, Christopher Godwin, Geoffrey Thun. "Ventilation Rates in Recently Constructed US School Classrooms," *Indoor Air*, 5: 880-890, 2017.

The lack of both wind- and temperature-driven effects affecting the indoor-outdoor pressure differential means that air infiltration through the building envelope would be minimal during the fire period.

4.3 Infiltration and particle penetration

Infiltration refers to the entry of outdoor air through the building envelope, including through very small cracks and pores. Particles in outdoor air may not be able to cross the building envelope and enter the building in the same manner as air since particles are very large and heavy relative to molecules of air, among other differences. The entry of particles into a building is called *particle penetration.* The ability of particles to enter a building is characterized by *penetration efficiency*, which depends on the physical and chemical properties of the pollutant and the building envelope, and the environmental conditions. The penetration efficiency of soot, char and ash can vary considerably due to their different properties, including their size, as noted below.

- Soot is a submicron (less than 1 µm) black powder[19] formed largely from "aciniform carbon," which is defined as colloidal carbon having a morphology consisting of spheroidal primary particles (nodules) fused together in aggregates of colloidal dimension in a shape having grape-like clusters or open branch-like structures; the colloidal particles are typically 20-50 nm in size (0.02 – 0.05 µm);[20] soot aggregates, chains and clusters are larger and span a large size range.
- Char is carbonaceous material that preserves the morphology of the precursor (e.g., wood) and includes particles greater than 1 µm size; [21] particle size may reach several mm (~2000 µm) though 1 – 500 µm is more typical.[22] The EMSL analyses showed char particles with sizes about 50-100 µm, [23] about the thickness of a human hair.
- Ash is the decarbonized residue of cellulosic material (e.g., burnt char), which may not preserve the original morphology and may have higher concentrations of inorganic compounds and be alkaline. Size can vary considerably, e.g., 0.5 to 1000 µm. [24]

Penetration efficiency depends strongly on particle size.[25] Penetration efficiency will be relatively high (roughly 75%) for particles in the range of 0.02 to 0.5 µm dia (smaller soot), decrease to roughly 30% for 5 µm diameter particles, and continue to fall, potentially much lower, for large particles, e.g., 50-100 µm char particles. Relevant estimates of penetration efficiency for large particles are not available in the literature.

The key points are (1) that penetration of particles through the building envelope differs from air infiltration, and (2) that penetration of large particles like much char can be substantially reduced.[26]

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[19] AIHA 2018. Ibid.

[20] ASTM, D6602−13. Standard Practice for Sampling and Testing of Possible Carbon Black Fugitive Emissions or Other Environmental Particulate, or Both, West Conshohocken, PA, 2018.

[21] ASTM, 2018, ibid.

[22] Kovar, B, ML King, P Chakravarty. Suggested guidelines for wildfire smoke damage investigations and remediation. J Cleaning Restoration and Inspection, June 2015.

[23] EMSL Analytical, Inc. Laboratory Report - Common Particle Identification Combustion-by-Products; Project: The Metropolitan 200 Route 130 North, Cinnaminson, NJ 08077. June 17, 2019.

[24] AIHA, 2018, ibid.

[25] Long, CH, et al. Using Time- and Size-Resolved Particulate Data To Quantify Indoor Penetration and Deposition Behavior, *Environ. Sci. Technol.* 35, 2089-2099, 2001.

[26] FBS, ibid. June 2020. On p. 19, FBS asserts: "It is important to note that negative pressures are less than ambient pressure, and positive pressures are greater than ambient pressure. When this condition exceeds the design of the building or the

4.4 Summary: limited potential for exposure, infiltration and penetration of fire-related pollutants

The Phase 1-3 buildings had little potential for significant exposure, air infiltration and particle penetration of fire-related pollutants. These buildings had neither the exposure nor a completed pathway required for the entry of fire-related combustion materials into the building. This is shown by the duration and dynamics of the fire, the prevailing meteorology, plume direction, the building configuration, the lack of conditions needed to cause infiltration and particle penetration through the building envelope, and the low penetration efficiency of large particles. This is further supported by the sampling results that showed few if any signs of combustion residues with moderate or high likelihood despite numerous samples collected (Section 6).

A portion of Phase 4 and Phase 5 had limited potential for smoke exposure due to their locations with respect to the prevailing winds and plume direction, however, the pathway for entry of fire-related combustion residues was not completed and thus the penetration of fire-related combustion residues into the building is likely to be minimal. Because the building envelope remained intact, the prevailing meteorology greatly favored vertical plume rise, and the conditions needed to cause air infiltration and particle penetration were absent, the likelihood that significant amounts of fire-related combustion residues entered these building is small. This is supported by the analysis of samples that showed moderate or high likelihood of combustion residues in very few and localized areas (Section 7).

The limited entry and presence of fire-related combustion residues in any of the Phase 1-6 buildings will be far too small to confer any meaningful risk of adverse health effects (Section 7).

5 Collection and Analysis of Samples by FBS

FBS conducted a number of inspections and collected environmental samples at the Metropolitan from Jan. 9, 2019 through August 27, 2020 that are pertinent to the assessment of fire-related combustion residues. The record shows a total of 15 sampling visits in which 471 samples were collected and analyzed. Samples included air (Air-o-cell cassettes), surface (tape and wipe) and bulk samples with analysis by two laboratories. For 14 of these visits, samples were analyzed optically by N.G. Carlson Analytical; the May 30th, 2019 visit used a "level 4" analysis that included soot confirmatory analysis using ASTM D6602 protocols conducted by EMSL. Results of all samples are presented in Table 2 and Appendix 1.

5.1 Sampling results

5.1.1 May 30, 2019 sampling

Following an initial site visit on April 24, 2019, FBS visited the site to "conduct soot sampling" on May 8, 2019; a second round of sampling occurred on May 30, 2019. FBS provided results of the sampling in a report dated June 5. 2019.[27] This section discusses the May 30, 2019 samples analyzed by EMSL. (All other samples collected by FBS were analyzed by N.G. Carlson Analytical.)

Table 2 lists results for the 20 wipe samples analyzed by EMSL.[28] The purpose of the EMSL analysis was to determine the identification of the collected particles, based on individual components (common components of environmental dust and combustion-by-products) using several analysis techniques, e.g., Polarized Light Microscopy (PLM), epi-Reflected Light Microscopy (RLM), Transmission Electron Microscopy (TEM),

design is compromised, say by a fire, heat or water from the fire infiltration will occur at the failure points." This is an incorrect description of infiltration.

[27] FBS. Fire Damage Report for The Metropolitan, June 5, 2019

[28] EMSL Analytical, Inc. Laboratory Report - Common Particle Identification Combustion-by-Products; Project: The Metropolitan 200 Route 130 North, Cinnaminson, NJ 08077. June 17, 2019.

Scanning Electron Microscopy (SEM), Energy-dispersive X-Ray Spectrometry (EDX), Electron Microscopy. Of most interest is soot, ash, and char, described by EMSL as:

- Black Carbon (Soot): a randomly formed particulate of carbon, commonly with a spherical to pseudo-spherical (aciniform) morphology. It is a by-product of uncontrolled combustion.
- Carbonized Material/ Char: a solid decomposition product of natural or synthetic origin that maintains, at least in part, its original form.
- Ash: Residue left after complete carbonization of the material. It does not maintain its original form.
- Charcoal: a term for char obtained from wood, peat, coal or other organic material.

EMSL notes that their limit of quantitation is ~1%. Two of 20 samples indicated the potential for fire-related residues: Sample 1A, identified as Phase IV – 4th Floor – Floor Truss, containing an estimated 15% char, and Sample 7A, identified as Unit 115 – bedroom window sash, containing an estimated 40% char. The PLM images for these samples show char particles on the order of 50-100 µm in size. No black carbon or other combustion products were identified in these samples. None of the other 18 samples indicated other fire-related material above the limit of quantitation, essentially showing normal or trace levels of combustion residues. The interpretation of the sampling results is hampered by documentation gaps, including the absence of the custody forms, sampling collection protocols, detailed maps and photographs of sampling locations (Section 5.2). The FBS report describing this sampling[29] contains a number of misleading and erroneous statements and data interpretations[30] (Section 5.2.4).

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[29] FBS, Supplemental Sampling Report, Forensic Building Science, Inc., Nov. 13, 2019.

[30] FBS, Nov. 13, 2019, ibid. For example, the report states that: "the results of the second round of sampling confirmed the presence of soot on surfaces throughout the structure," (p.2), and "17 surface samples showed signs of particulates consistent with the fire." (p. 3)

Table 2. Results for 20 wipe samples collected by FBS on May 30, 2019 and analyzed by EMSL. Percent of particles shown. Two samples highlighted where char was detected above the level of quantitation.

Descriptor		1A Phase IV – 4th Floor – Floor Truss	2A Unit 404 – closet door header	3A Unit 422 – Living room - baseboard	4A 4th floor – SW maintenance closet – N. painted drywall	5A Unit 217 – Bedroom door header	6A Unit 221 – bathroom closet door header	7A Unit 115 – bedroom window sash	8A Unit 117 – living room – upper window sill	9A Unit 121 – entry door header	10A Unit 122 – Laundry room baseboard	11A Unit 217 – kitchen can light fixture – ceiling cavity	12A 2nd floor – SW maintenance closet – top of meter	13A 2nd floor – W. hallway (outside 202) top of emergency light	14A 2nd floor – W. hallway (outside 324) Painted drywall	15A 3rd floor – NW maintenance closet – E. painted drywall	16A 3rd floor – S. hallway (outside 316) ceiling access cavity	17A 3rd floor – NW maintenance closet – E. painted drywall	18A 3rd floor – W. hallway (outside 304) ceiling access cavity	19A 4th floor – N. hallway (outside 430) top of emergency light	20A 4th floor – W. hallway @ stairway – tip of fire extinguisher
Combustion-by-products	Char	15	<1	<1	<1	<1	<1	40	<1	<1	ND	<1	<1	<1	<1	ND	<1	ND	1	<1	<1
	Ash	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Black Carbon /Soot	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Carbon Black	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Asbestos:	Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MMVF's:	Total	<1	<1	ND	ND	<1	<1	<1	<1	ND	ND	<1	<1	<1	ND	ND	2	ND	2	1	<1
Cellulose:	Processed / Paper Pulp	30	10	15	20	10	10	10	5	2	10	10	2	5	30	10	25	5	15	5	5
	Natural / Wood Dust	<1	<1	ND	<1	<1	<1	<1	<1	ND	ND	<1	ND	ND	ND	ND	ND	ND	2	ND	ND
	Starch	<1	ND	ND	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND	<1	ND	ND	ND	ND	ND	ND
Synthetics:	Total	5	2	30	25	10	30	15	25	10	10	20	10	10	15	15	15	10	5	15	20
Hair:	Human	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Animal	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Biological:	Skin Fragments	<1	ND	<1	ND	<1	ND	<1	ND	ND	ND	1	ND	<1	<1	<1	ND	ND	<1	<1	<1
	Insect Fragments	<1	<1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	<1
	Dust Mites	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Spider Silk	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mold	<1	<1	ND	ND	ND	ND	<1	<1	ND	ND	ND	ND	<1	ND	<1	<1	ND	1	<1	<1
	Pollen	<1	<1	<1	ND	<1	ND	<1	<1	ND	<1	ND	ND	<1	ND	ND	<1	ND	<1	<1	<1
Mineral:	Quartz (Sand)	5	15	5	2	10	2	10	10	15	2	2	20	10	5	5	5	2	10	15	10
	Calcite/ Dolomite	2	15	5	2	20	10	5	30	30	2	2	15	30	5	5	5	2	5	20	20
Sample Specific	Gypsum/Anhydrite	2	5	2	1	5	N/A	1	5	7	15	35	2	10	2	1	10	1	25	10	10
	Environmental Dust**	34	47	40	47	40	45	14	20	35	60	27	49	30	40	62	34	80	32	30	29

5.1.2 Jan. 9, 2019 and May 8, 2019 through Sept. 11, 2020 sampling.

In 14 sampling events (several spanning 2 days), FBS collected 451 air, bulk and tape samples, subsequently analyzed by NG Carlson Analytical. As noted in each Carlson report, "no chemical identification was conducted on the soot-like, char-like particles, and carbon black-like particles. Presumptive identification was based on particle morphology." Quantitation appears to use particle counts; no standard operating procedure was provided, a deficiency discussed in Section 5.2.[31] Each report provides tabular results, a short discussion, custody forms, and for selected samples, micrographs and some notes.

The air samples appeared to use 30-75 L samples (some volumes are not documented), Aer-o-cell cassettes, and light microscopy analysis. Air samples were reported on a non-standard scale of 1 to 50+, which appears to be the average number of particles per field view at 400x power (p. 5).[32] Because the air samples used at least two sampling volumes (30 L, 75 L, and "XX" L – the latter which cannot be interpreted), adjustments to the data may be warranted to allow inter-comparison of samples, both within and between sampling events; such adjustments are not documented and do not seem to have been performed.

Table 3 summarizes the data collected in these 14 visits; the full set of NG Carlson data has been consolidated and is presented in Appendix 1.

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[31] NG Carlson noted the following in each report to interpret carbon black, char and soot-like particles: "Less than 0.5 particles per field (400x) – negligible impact of smoke; 0.5 and 2.0 particles per field (400x) – limited impact of smoke; 2.0 and 10 particles per field (400x) – moderate impact of smoke; 10 – 50 particles per field (400x) – significant impact of smoke."

[32] Carlson NG, Expert Report, 10/5/20. In this report, p. 5 noted that the concentration (#/m3) can be obtained by using the score or average count reported and the sampling volume. Examples are given that show that the concentration (#/m3) = (average count reported per view) x (field views per trace) / (volume sampled in m3). It also states there are nominally 25 field views per trace. This is considerably fewer than the 100 views suggested in some standards and guidelines. The concentration calculation appears to imply that the entire trace is covered without double counting. It also does not represent the number density or area density of potential combustion residues, which are the more standard approach in this application. Most significantly, it also means that the same score has a different interpretation for samples with different sampling volumes, i.e., a score of 2 with a sampling volume of 30 L means a concentration that is 2.5 times higher than a score of 2 with a sampling volume of 75 L. Although relatively few air samples showed significant likelihood of combustion residues, it appears that adjustment of the data is required to compare the 30 and 75 L sample results. Specifically, the 75 L samples may have 2.5 times the level shown for a 30 L sample, other things being equal.

Table 3. Summary of 15 sampling events conducted by FBS at the Metropolitan.

Sample Date	Type and quantity	Location	Findings	Interpretation	No. high likelihood	Errors
1/9/19	25 air samples collected	Phases 1-3?; main level and 4th floor	6 samples with moderate likelihood of combustion residues; 7 samples with high likelihood of combustion residues (most identified as "carbon black", however, 9 of these in kitchen areas.	Most samples show normal conditions; some samples may contain cooking-related carbon particles; high likelihood of combustion particles identified in corridor in 2 samples (7, 12)	2 samples in corridor	Sample 9 reports <11 for char; samples inconsistently report soot, carbon black, and combined soot/carbon black. Inadequate documentation, e.g., cannot tell which samples had "sterilized inner-wall sampling adapters were used at select predetermined locations and cavities".
1/28-29/20	32 air samples collected	Phase? 3rd and 4th floors	All negative or trace; one kitchen sample showed low combustion residues (3-4% char)	All samples show normal conditions; one sample shows low likelihood of combustion residues, but may be kitchen related material	0 samples	No outside air sample for comparison
	49 tape and 3 bulk samples collected	Phase? 3rd and 4th floors	1 bulk sample on sheetrock in Unit 422 (47B) showed medium likelihood of combustion residues ; 1 tape sample in Unit 307 on bedroom wall (69T) showed high likelihood, but notes indicate could be paint particles, which are widespread	All samples identified as normal condition, except 1 sample with medium likelihood of combustion residues	0 samples	Paint-like particles inconsistently characterized, e.g., micrograph for sample 67T describes paint, but not quantified in data
2/25/20	15 air samples collected	Phase? 3rd floor	All negative or trace	Normal conditions	0 samples	No outside air sample collected. No air sampling volume reported. No calibration for pump indicated. Cannot interpret adequately. Report indicates samples collected Feb 13 2020 and Feb 25, 2020. Former date appears incorrect.
	18 tape and 2 bulk samples	Phase ? 3rd floor	All negative	Normal conditions	0 samples	
3/11/20	18 air samples collected	Phase ? 2nd and 3rd floors	All negative	Normal conditions	0 samples	No outside air sample for comparison. Noted as 2-min samples, presumed to be 30 L, but no documentation. Discussion states "Char and Soot levels varied from Negligible to Limited on the Air-o-cell cassette samples" but no PFRS quantified.
	20 tape and 2 bulk samples collected	Phase? 2nd and 3rd floors	All negative	Normal conditions	0 samples	Discussion states "Char and Soot levels varied from Negligible to Limited on the bulk and tease tape samples" but no PFRS quantified.
3/19/20	14 air samples collected	Phase ? Mostly 1st floor. Some unknown.	All negative	Normal conditions	0 samples	No outside air sample for comparison. Noted as 5-min samples, increase from prior practice. No calibration or volume given. presumed to be 30 L, but no documentation.
	13 tape and 1 bulk sample	Phase ? Mostly 1st floor. Some	All negative	Normal conditions	0 samples	
3/24-25/2020	13 tape samples collected	Phase 5, mostly 4th floor other	All negative except for 1 sample (11) for unit 427 bedroom window sheathing showing 1-15% of char	Normal conditions, or moderate likelihood of fire residues	0 sample (taking most likely value)	Large range; could resample location.
4/7/20	5 bulk and 1 tape (uncertain documentation) collected	Phase ?, northwest and southwest corners?	All negative except sample 5 low (2-4%) char on Zip sheathing	Normal conditions; low likelihood of combustion residues	0 samples	Standard chain of custody form not used; Inconsistent labeling: Sample 4 indicated as tape sample in report; sample 6 indicated as bulk sample on hand written documentation (p100 report)

Table 3 continued

Sample Date	Type and quantity	Location	Findings	Interpretation	No. high likelihood	Errors
4/8/20	4 air samples collected in elevators 1 and 2	Phase? Floors 1 and 4	3 negative, but sample 4A (elevator 1, floor 4) shows 5-10% char, but note indicates "The char shape was irregular and could be a false positive."	Normal conditions; low likelihood of combustion residues	0 samples	
5/8/20	25 air samples collected in phases 1-4 at all levels	Phases 1-4; Ground floor, 1st-4th floors	6 samples showed moderate levels of char or soot (5-10%); 5 samples showed high levels of char or soot (11-50%); Highest (sample 29) was kitchen island in Unit 336; Two highest samples (29 and 31) stated to have very heavy trace and note indicates count is approximate	Most samples show normal conditions; 6 show medium likelihood of combustion residues in phases 1-3; high likelihood of combustion residues in 3 samples in phases 1 and 3; possibly high likelihood in 2 additional samples	3 to 5 samples	Volume of sample changes from 30 to 75 L without rationale no calibration noted; No outside air sample for comparison. Micrographs of most highly loaded filters not provided.
	44 tape samples, 3 bulk samples of insulation or air filter	Phases 1-4, floors 1-4	15 samples showed moderate levels (5-10%) of char, soot or carbon black on roof AC cover, hallways, window sill, closet outlet boxes, "above" doorways, subfloor dryer ducts. 16 samples showed high levels of these components, included samples in Unit 219, mechanical room in Phase 1, joist near Unit 240; surfaces in Units 344, 438, 138, 452, 457, ; unspecified exterior behind sheathing in Phase 1. High levels found on several exterior wall samples behind siding and in joist	Unlike prior sampling due to higher levels of char, soot, carbon black. Some samples show normal conditions; 15 show medium likelihood of combustion residues; 16 show high likelihood. Units 219 and 348 show high likelihood in both air and tape samples. More samples show combination of soot, char, ash than most other sampling.	16 samples	Locations on exterior walls not specified. Micrographs provided for only 6 samples
5/30/19	20 wipe samples collected; analyzed by EMSL	1st - 4th floors, some cavities	18 samples negative or trace. 2 samples with high char (1A; Phase 4 4th floor truss; 7A Unit 115, bedroom window sash); Stated to be comparison with 5/8/20 sampling;	Most samples show normal conditions; two show high likelihood of combustion residues.	2 samples	Report states "the results of the second round of sampling confirmed the presence of soot on surfaces throughout the structure"; and "17 surface samples showed signs of particulates consistent with the fire"
7/16/20	17 air samples collected	7 samples appear to be in parking area or storage area, uninhabited area; 9 samples from 4th floor	For the parking samples: 3 samples show moderate char; 2 samples show high char. For the 4th floor samples, 2 samples show moderate char. The outdoor sample shows high char (10-15%)	The outdoor sample exceeds all but 2 samples, which were collected in the parking area. May represent baseline or background level, indicating no combustion projects detected except for 2 samples in the parking area.	2 samples (uninhabited area)	Several samples use the same identification number, 1A, 4A, 14A. Only micrographs for 11A and 14A (from garage) are included.
	26 tape and 1 bulk sample collected	9 in parking area, not inhabited area; 16 mostly on 4th floor	For the parking area samples: 1 sample show moderate char and 2 show high char. For the indoor samples, 2 samples shows moderate char and 2 samples showed high char; these indoor samples are sheathing or studs around units 441 and 442.	High likelihood of combustion residues on 2 indoor samples, appear to be under sheathing or on studs	2 samples in occupied area; 2 samples in uninhabited area)	Several samples use the same identification number, 2T, 5T, 6T, 10T, 15T. Only selected micrographs are included. (3 samples with char)
8/11-12/2020	14 air samples collected	Outside and 3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	
	12 tape samples collected	3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	
8/25/20	14 air samples collected	3rd and 4th floors	All negative or trace	Normal conditions.	0 samples	No outdoor sample collected as reference or background.
	20 tape samples collected	3rd and 4th floors	All negative or trace except for soot (20-30%) in Unit 303 mechanical room, however, notes on this sample indicate "particle similar to soot" but largely paint	Normal conditions with one uncertain sample, possibly high likelihood	Possibly 1 sample	Lacking recheck of suspect sample; Unit 38 entered but no such space
8/27/20	8 air samples collected	2nd floor	Negative or trace for all samples except 1 sample (P) fire equipment area near Unit 236 with high char (20-25%) however noted as "atypical char", not noted in Discussion. Micrograph for this sample shows mold Cladosporium, not char	Normal conditions at all but one location with high char but note indicates atypical, thus discounted.	0 samples.	No outdoor air reference or comparison sample. No micrograph of suspect sample showing char.
	8 tape samples collected	2nd floor	All negative or trace	Normal conditions.	0 samples	
9/11/20	12 air samples collected	Mostly phase 4, floor 1	All negative or trace	Normal conditions likely, however, QA is absent due to reporting omissions.	0 samples	Does not specify volume of air sampled; Did not specify location. Added location from custody form.
	12 tape samples collected	1st floor	All negative or trace	Normal conditions	0 samples	Custody form inappropriately utilized

5.2 Evaluation of FBS sampling, analysis, and interpretation

The 15 sampling events at the Metropolitan included the collection and analysis of airborne, wipe, surface and bulk samples. This section evaluates data quality, and the analysis and interpretation of this data by FBS.

5.2.1 Lack of sampling design suitable for assessing indoor environmental quality

The purpose of FBS's sampling appears to be to determine whether fire-related combustion residues (i.e., ash, char and or soot) had spread to other parts of the structure.[33] NG Carlson Analytical notes that some reports are "initial screenings" (report #14); other reports <unspecified report number> are "focused on the effectiveness of remediation and identifying by the arson fire and if there may be possible interior sources of fungal growth. Additional reports focused on the effectiveness of the remediation techniques and identifying other areas of concern as wall cavities were opened. Subsequent reports also addressed concerns about fungal growth as thought to be attributed to the fire suppression or concerns about water infiltration of the building envelope."[34] This suggests that at least some of the sampling represented a screening level approach, typically used to determine whether additional sampling is warranted. Most determinations of combustion residues, specifically soot, char and ash, were based on optical analyses, and excepting the 20 EMSL-analyzed samples, no chemical analyses of the collected samples were performed.

FBS collected and analyzed 198 air samples, collected from Jan. 1, 2019 through Sept. 11, 2020, 96 to 715 days after the fire. Except for the initial 25 samples, the air samples were collected starting on Jan. 28, 2020, 488 days after the fire. Char, soot ash or other fire-related combustion residues from the Sept. 27, 2018 fire could not stay airborne in a building environment for this period of time. Rather, the air samples most likely reflect contemporary sources of particles (e.g., cooking, cigarette smoke, outdoor pollutants, etc.) and not fire-related combustion residues unless materials were recently disturbed (e.g., during or prior to sampling). As noted below, it is essential to obtain background or reference measurements for environmental sampling to show whether measurements are elevated beyond normal conditions. This is particularly important for air samples as indoor and outdoor levels can change rapidly in time.

The sampling and analysis conducted by FBS at the Metropolitan were not designed to determine whether fire-related combustion residues compromised indoor environmental quality or could cause adverse health impacts of occupants at the Metropolitan. Such sampling would address the potential for occupant exposure and health risks from toxic substances. Instead, sampling focused on visual analysis and optical analyses of the presence of char, ash and soot on building surfaces and building cavities. As noted later in Section 7, a number of the locations sampled would present extremely limited potential for exposure and health impacts even if combustion residues were identified. FBS did not obtain or present any data regarding the concentration of potentially toxic chemicals in the detected combustion residues, and FBS did not conduct a quantitative assessment of the potential to cause adverse health effects.

[33] FBS, p. 49, June 2020 and Oct. 5, 2020 (p. 67) state: "The primary purpose of the sample collection was to determine whether ash, char and or soot consistent with base line samples taken from the surviving portion of the building closest to the fire-destroyed building had spread to other parts of the structure. Our investigation focused on hidden cavities typically overlooked during smoke damage cleaning efforts. These included the wall cavities, ceiling assemblies, mechanicals, electrical boxes and areas around the elevator hoistway in the building to aid in determining a proper scope of repair."

[34] NG Carlson, Expert Report in the Case of Maxus/The Metropolitan, Oct. 5, 2020.

5.2.2 Failure to follow standard sampling and analysis procedures

Sampling and analysis procedures and reporting by FBS and their consultants have numerous serious flaws and do not comply with standard practices, for multiple reasons (e.g., IESO/RIA Standard – 6001)[35] Some of these are indicated in the data summary shown in Table 3 (right hand column). Flaws include:

- Lack of blanks needed to assure appropriate sample collection practice and sample integrity during sampling, transport and storage of samples.
- Omission of standard operating procedures (SOPs) for collecting, labeling, transporting, storing, analyzing and interpreting samples and analytical data.[36] This includes the *chain of custody of samples*, which is largely unknown.
- Unknown adherence to SOPs, if they existed. This is exacerbated by the documentation gaps for the field activities. The documentation available shows many errors.
- Inadequate documentation, e.g., failure to include, for each sample, photographic documentation of inspection and sampling location surface (including type of surface, size/weight of area sampled, whether it was interior, exterior or cavity space, etc.)
- Documentation errors, e.g., samples taken at locations that do not appear to exist (e.g., Unit 38) and without specificity sufficient to identify sample locations (e.g., "NW corner of building sheathing", "corridor outside stair enclosure"), and air sample volume ("XXX"). Maps of sampling results are largely illegible and impossible to interpret or verify.
- Insufficient detail and inconsistent use of data entry forms for field sampling.
- Inconsistent and non-standard means to sample, quantify and present results of air sampling. In addition to the quantification issue (see footnote 32 earlier), NG Carlson noted that the air samples were short duration samples (1-5 minutes) with sampling time (or sample volume) based on "the professional judgment of the person doing the sampling with feedback from the person analyzing the sample" (p. 5). My review showed sampling times from 2-5 minutes without documentation as to why some samples had shorter or longer sampling periods and how this would have affected results.

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[35] IESO/RIA Standard 6001: Evaluation of Heating Ventilating and Air Conditioning (HVAC) surfaces to Determine the Presence of Fire-related Particulate as a result of A Fire in a Structure. Indoor Environmental Standards Organization. 2012.

[36] The best description of the sampling approach appears to be in the FBS Fire Damage Report, June 5, 2019, p. 34-5: "All air samples were collected with a Zefon Bio-Pump Plus air sampling pump calibrated to run at a volume of 15 liters per minute. The sample duration varied by location. The air samples were collected with Air-O-Cell sampling cassettes using standard accepted sampling techniques. Analysis of all Air-O-Cell cassettes was by a CIH and was presumptive consistent with industry accepted norms and based on the training, education and experience of the industrial hygienist.

The ambient air samples were collected for a five-minute sample period to use for comparison purposes. The wall cavity air samples were collected with the use of a sterile wall cavity adapter tube. Each tube was used only once, then discarded. At each wall cavity, the tube was inserted into the wall/ceiling or conduit/pipe space as far as possible.

The tape lifts were collected on wall or ceiling surfaces where the presence of char and soot was suspected to exist. There was evidence of extensive cleaning and demolition associated with repairs after the fire. Bulk samples of furnace filters were taken from units that were available to rent to determine if contaminants were present in the ambient air. Tape lifts were analyzed using four different methods to compare with presumptive Air-O-Cell cassettes sample analysis. Concurrent tape lift samples were taken at the origin location along with numerous other locations for baseline comparison purposes between presumptive analysis and more definitive analysis." Emphasis added.

- Inconsistent and qualitative mold sampling. In a most cases, a few mold species were identified optically and recorded with a "+", "++", "+++", or "++++". These marking are not quantitative,[37] and species identification is inadequate. In a few cases, mold concentrations were expressed as counts per cubic meter, the standard approach. The SOP utilized for mold is undocumented.
- Failure to use a certified laboratory. Laboratories that are certified in recognition of their ability to process samples and generate data that meets a minimal standard of quality and performance. Certifications by AIHA, CNAS and others are customary practice, well recognized, and essential. The bulk of analyses at the Metropolitan were performed by NG Carlson, Inc., a laboratory that does not appear to have any certification. For critical applications (and frankly to obtain business), laboratories obtain certifications, undergo regular audits and inspections, often by third parties, test QA samples, and perform many other activities aimed at documenting and maintaining the quality of protocols and results obtained. This deficiency is particularly critical when laboratory results inform significant decisions since the reliability of results is unknown. The lack of certification is often a sufficient reason to dismiss analytical results.
- Failure to have a certified industrial hygienist approve and monitor implementation of the sampling plan. Professional certifications by AIHA and others are well recognized and provide a level of assurance that the data generated will meet a minimum standard of quality and relevance to a defined problem. No peer-review of the sampling plan, data, or analysis was evident. Errors and omissions documented throughout this section demonstrate the significance of this failure.

5.2.3 Failure to measure and account for normal and background levels in sampling and analysis

It is well known that there are many sources of combustion residues in the environment and that samples collected must be to a reference or comparison level.[38] No reference or comparison samples were collected in most sampling events, and no comparisons to references levels were performed. While several air samples were collected that were noted as outdoor or ambient samples that may serve the purpose of a reference sample, no tape or bulk samples were designated as reference or comparison level samples, and no comparisons were made.

A low or trace level of a combustion residue reported in a sample does not indicate a meaningful likelihood of a fire-related impact. FBS implied that any detection of char, soot or ash, including <1%, indicated significant fire-related impacts. This fails to comply with the need (and guidance and customary practice) to use comparisons to reference levels to interpret sampling results. At the Metropolitan, one result of this practice is to produce *false positives* and *phantom risks* (Sections 5.2 and 6).

Accounting for background or reference levels is important for all types of samples. As in many urban areas, there is an abundance of sources of soot and other combustion residues near the Metropolitan. These include major highways and traffic-related sources and food establishments, especially those using grilling, barbequing,

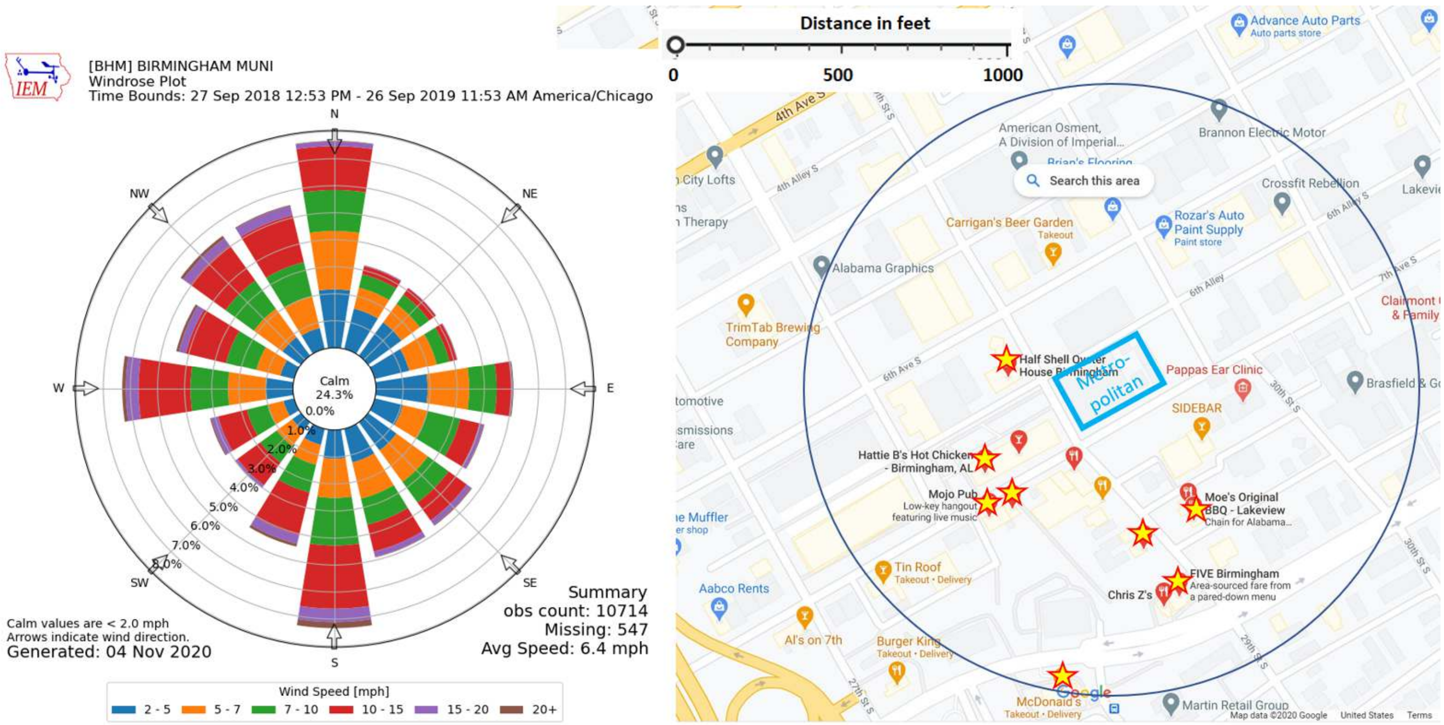
[37] Addendum C – Carlson Report, p. 54 provides some explanation, but the modifications are not document. The Report notes: "Fungal spore interpretation: Modified from IICRC S520. 0 No spores present + Normal spore deposition; ++ Heavier than normal spore distribution no growth noted; +++ Spotty fungal growth; ++++ Heavy Fungal growth."

[38] AIHA 2018, ibid, states (p18): "… establishing a baseline by determining normal background concentrations for the subject site are key in interpretation of field data. EPA 838/08 Site Contamination – Determination of Background Concentration and EPA 540/F-94/030 Establishing Background Levels specify that background sampling locations must be selected from areas on the site or near the site not known to be impacted by combustion particles from the fire event. Combustion particles from everyday activities such as wood burning fireplaces, stoves, candles, cigarettes, and vehicle exhaust are part of the background. Emphasis added.

As an example of the disregard for consideration of normal background levels, the Fire Report, p 59, states: "Of the 72 air, tape and bulk grab samples taken and submitted for analysis, some level of byproducts consistent with the fire were found in all the samples, including soot, char, and ash (100%). Of the 72 samples taken and submitted for analysis, 12 samples showed less than 1% of soot, char, and ash. The remaining 60% of samples had results in excess of 1%. "

smoking and frying, all known to emit significant quantities of soot and carbon aerosols. There are many such establishments in Birmingham and the Lakeview area, including at least eight within 1000 feet of the Metropolitan, some of which may burn wood. Figure 8 shows locations of restaurants serving grilled, barbequed and fried foods, e.g., Hattie B's Hot Chicken within 300 feet of the Metropolitan, and Moe's Original BBQ within 375 feet. The Metropolitan is frequently downwind of these restaurants, as shown by the wind rose in Figure 5.[39] A significant background level of PAHs is expected and from such sources, which is confirmed by air pollution measurements at four Birmingham locations where the most toxic PAH (BaP) exceeded health-based screening levels, i.e., BaP in ambient air averaged 0.002 μg/m^3 and reached 0.015 μg/m^3, or 7.5 times the screening level discussed in Section 7.3.[40]

Figure 5. Left: Wind rose from the Birmingham Airport for the 1 year period following the fire. Right: Map identifying restaurants (as stars) that grill, barbeque or fry foods within 1000 feet buffer of Metropolitan using Google Maps,



39 Wind rose shows direction wind is blowing from. Using data from Birmingham airport. Generated using Iowa Environmental Mesonet: Wind Rose Plotsttps://mesonet.agron.iastate.edu/sites/dyn_windrose.phtmls.

40 Jefferson County Department Of Health, Birmingham. Air Toxics Study. February 2009 https://www.epa.gov/sites/production/files/2020-01/documents/jeffersoncountyfr.pdf. On p.36: Benzo(a)pyrene is a polycyclic aromatic hydrocarbon (PAH) that exceeded the chronic cancer risk at North Birmingham and Shuttlesworth. This compound is highly carcinogenic and its emissions are closely associated with coal tar, automobile exhaust, cigarette smoke and wood-burning.

5.2.4 Flawed and misleading interpretations and conclusions by FBS

FBS describes the generic nature of fire pollutants and settled combustion residues and concludes that their presence is hazardous.[41] There is little if any relevant documentation that supports this conclusion, e.g., no consolidation of data, no analysis by location, no consideration of exposure potential, background or reference levels, no relevant chemical analysis, and no discussion of cleanup and restoration practices that would inform an evidence-based conclusion.

5.3 Summary

The FBS sampling and analysis at the Metropolitan has many significant flaws and omissions. These include significant documentation gaps and data presentation issues, unknown or inappropriate sampling and analysis protocols, unknown chain-of-custody procedures; the lack of background or reference samples, the lack of analyses measuring concentrations of toxic chemicals to inform health risk evaluations; the lack of a certified laboratory to perform analyses; the lack of a certified competent individual to approve, monitor and interpret the sampling plan and results obtained. As a result, data quality is unknown, and the data are potentially unreliable and inadequate for supporting the data interpretations needed to evaluate the building condition and its suitability for occupancy. In addition, the data do not appear to have been consolidated in a coherent manner, subjected to appropriate QA, or interpreted and analyzed appropriately. Given these many flaws and deficiencies, the conclusion drawn by FBS utilizing these data that widespread and serious contamination by fire-related combustion residues is specious.

6 Reassessment of the FBS sampling data

To interpret the sampling data, a consolidated data base was assembled; sampling results were interpreted with respect to the likelihood of fire-related combustion residue; and data were presented in tabular and graphical forms to aid interpretation. While most of the flaws pertaining to sampling and analysis noted in the prior section cannot be resolved, this section uses the FBS data to see what the data indicated.

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41 FBS, Oct. 5, 2020, ibid. p. 50 asserts: "I agree "there are no health-based standards or exposure limits", therefore these combustion byproducts from the fire must be removed. Several studies cited in this report [See Figures 48-50 below and Addendum B] discuss the health risks associated with exposure to certain size combustion byproducts. FBS sampled specifically for these combustion byproducts consistent with the fire and the design of the complex. particulates based on micron sizes under 10. [See Figure 48 below] In my opinion, and in consultation with Baxter and Carlson, the particulates we found are a health risk and must be removed." Emphasis added. In addition to conflating the potential for hazard and likely risk, this statement and the EPA graphic in the document refers to $PM_{2.5}$ emissions during the active fire phase, which is irrelevant.

p.51 continues: "Soot is a general term that refers to the black, impure carbon particles resulting from the incomplete combustion of a hydrocarbon. It is more properly restricted to the product of the gas-phase combustion process but is commonly extended to include the residual pyrolyzed fuel particles such as cenospheres, charred wood, petroleum coke, etc. that may become airborne during pyrolysis and which are more properly identified as cokes or chars. The gas-phase soots contain polycyclic aromatic hydrocarbons (PAHs). The PAHs in soot are known mutagens and probable human carcinogens. Soot is in the general category of airborne particulate matter, and as such is considered hazardous to the lungs and general health. Soot is classified as a "Known Human Carcinogen" by the International Agency for Research on Cancer" (IARC). Emphasis added.

On p.42: "Among hydrocarbons produced by the fire and embedded in the combustion byproducts, the poly aromatic hydrocarbons (PAHs) are the main carcinogenic compounds in the soot. Below is a diagram that outlines the issues related to these PAH's." Emphasis added. The report then highlights a diagram of showing biological pathways.

On p. 56, FBS asserts: "In my opinion, as there is not an acceptable level for exposure, the combustion byproducts from the fire found in this building should be removed. Emphasis added.

6.1 Generation of a consolidated database

Despite the issues discussed in Section 5, a consolidated database containing the FBS data was assembled and analyzed. Considerable effort was taken to clean up and correct data locations and other details, where possible, based on close examination of custody forms and the laboratory analytical reports.

6.2 Likelihood of combustion residues

The quality and interpretation of indoor and environmental data is affected by many factors. As suggested in Section 5, these include:

- Inadvertent contamination of samples during sampling, sample transport and/or sample storage. Contamination can be minimized by following best practices and standard operating procedures. For the Metropolitan, many issues are present, e.g., there is no record of blanks that would help document such contamination.
- Uncertainty and errors in laboratory determinations. Visual estimates of combustion residues are highly inaccurate (factor of two) when particle coverage is below 10% and count estimates can be affected by many factors, e.g., morphological heterogeneity.[42] For this and other reasons, laboratories flag questionable data, determine and specify precision, detection and quantification limits, and utilize other means to document data quality and aid interpretation.
- Significance levels to document measurements elevated above normal levels. Numerous sources emit combustion-related particles that are found on essentially all surfaces, and thus sampling results must be compared to reference levels. Soot and PAHs are ubiquitous, for example, arising from countless everyday activities, both indoors and outdoors. Sampling at the Metropolitan included few if any background samples or comparisons (Section 5.2.3).

Data interpretations must account for these realities and use approaches that recognize and minimize *false positives*, called *phantom risks*. For the Metropolitan, this means declaring the presence of fire-related combustion residues and health risks when in fact this is not true and only normal levels of combustion residues are present. A simple, effective and widely used approach is to classify sampling results as having *low, moderate or high likelihood* of showing fire-related combustion residues, based on the entirety of the evidence and accounting for the sampling, laboratory and environmental factors mentioned. It is customary to base classification on the proportion or relatively percentage of different components, called a *ratio analysis*, e.g., the percentage of identified fire residue particles of the total biological and inorganic particles measured. Percentages exceeding approximately 5% indicate an increasing probability of fire residue contamination; percentages above approximately 10% provide stronger evidence.[43 44 45]

Table 3 consolidates several guidelines and expresses conditions for moderate and high likelihood of combustion residues. Ideally, an assessment of moderate to high likelihood of impact would also utilize a *loading or concentration analysis*, since a sufficient number or concentration of particles, loading, or surface concentration

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[42] Kovar, Brad, Russ Crutcher, Heidie Bettes. Wildfire Smoke Exposure: a Comparative Study between Two Analytical Approaches; Particle Assemblage Analysis and Soot, Char and Ash Analysis. https://www.safeguardenviro.com/wp-content/uploads/Wildfire-Smoke-Exposure-a-Comparative-Study-between-Two-Analytical-Approaches-Particle-Assemblage-Analysis-and-Soot-Char-and-Ash-Analysis.pdf

[43] Delia, A, D. Baxter, The ABCs of Wildfire Residue Contamination Testing, *The Synergist*, 2017.

[44] Millette, James R., William Turner Jr., Whitney B. Hill, Pronda Few, J. Philip Kyle. Microscopic Investigation of Outdoor "Sooty" Surface Problems, *Environmental Forensics*, 8:1-2, 37-51, 2007.

[45] Alcaraz, X., Wildfire Residues Assessment and Restoration – A Case Study of the 2017 NorCal Fires, BSI, March 7, 2019.

is necessary to be meaningful from a health perspective (Section 7.3). Particle counts (as can be inferred), loadings, or concentrations were not provided by FBS, thus a loading/concentration criterion was not applied. Nevertheless, the use of the ratio analysis and the interpretation in Table 3 provide a consistent and evidence-based approach to interpret the sampling results.

Table 4. Classification of likelihood of combustion residues. Interpretation based in part on Sonoma County risk management approach in Alcaraz (2019).

Density of Identified Combustion-Related Residues	**Likelihood of fire-related Combustion Residues**	**Interpretation**
ND, Trace, 2%	Normal	Typical of recently cleaned surfaces and/or building surfaces w ith minimal or no combustion residues detected.
3% - 4%	Low	Minor presence of combustion residues detected which may be from various sources.
5% - 10%	Moderate	Moderate presence of combustion residues detected beyond normal conditions.
>10%	High	High presence of combustion residues detected beyond normal conditions.

Each sample was reviewed according to the criteria in Table 3 and classified as having normal, low, moderate or high likelihood of combustion residues. To be conservative, the highest value among soot (or black carbon), char and ash determinations was utilized. In the few cases were results where expressed as a range, the range limits were averaged, e.g., a range of 5-15% was considered >10%. For a few samples, data considered likely to have quantitation errors or not indicate fire-related combustion residues were flagged to have low confidence. The evaluation emphasized moderate and high likelihood samples, and considered potential sampling and analysis errors, sample type (air or tape), and sample locations (occupied spaces, building cavities, etc.) as could be determined from the available documentation. Classification of a sample as moderate or high likelihood of combustion residues does not indicate moderate or high health risk, but only the source of particles. Health risks must include consideration of the chemicals, concentrations, exposures and toxicity (Section 7).

6.2.1 Assessment and mapping of FBS data

Table 5 summarizes the number of samples collected by FBS and analyzed by Carlson, representing 14 sampling events and 451 samples. These were grouped by sample location, degree of confidence, and sample location. Low confidence samples had quantitation errors or questions indicated by NG Carlson (sometimes found in the notes on the micrographs), or were air samples collected in kitchens in occupied or previously occupied units with high likelihood of reflecting cooking-related soot. Tables 6 and 7 list all samples, sorted by location and date, which had moderate and high likelihood, respectively. The 20 samples analyzed by EMSL had two such samples (Table 2).

Overall, 40 of the 451 samples had measurement determinations that initially placed them in the high likelihood classification of representing combustion residues. However, 9 of these samples were considered low confidence, and 16 were collected in locations outside the residual units (e.g., parking area, hallways, including a number of areas that could not be determined). Of the remaining samples, 7 tape samples suggested 7 units (1 each on floors 2 and 3, and 5 on floor 4) that provided high likelihood of combustion residues in living spaces; these were found in localized areas on floors 2, 3 and 4. Several of these samples were borderline "high", appear to have

been collected on interior surfaces completed well after the fire, or have other anomalies. These are mapped and discussed in detail next. Overall, a small percentage of samples had a high likelihood of combustion residues.

Table 5. Number of samples collected by FBS and analyzed by Carlson. Grouped by sample type, whether sample was collected inside a housing unit, whether sample had moderate or high likelihood of representing fire-related combustion residues, whether quantitation and identification was likely to reflect fire-related combustion residues, and whether sample was collected in the occupied space (non-structural area).

			Moderate Likelihood				High Likelihood			
Sample Type	Samples Collected	Samples Collected Insid Units	Any	OK Confidence	OK Confidence, Inside Unit	OK Confidence, Inside Unit, Occupied Space	Any	OK Confidence	OK Confidence, Inside Unit	OK Confidence, Inside Unit, Occupied Space
Air	198	137	19	17	6	6	17	11	5	4
Tape	223	170	14	14	9	7	23	20	10	7
Bulk	30	22	2	2	2	1	0	0	0	0
Total	451	329	35	33	17	14	40	31	15	11

Table 6. Samples analyzed by NG Carlson with moderate likelihood of combustion residues.

Date	Inside Unit	Type	Vol	ID-Carlson	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Notes	Additional notes
5/8/20	219	Tape	-	10	Unit 219 – Bedroom 2 – Door Trim		-	5-10	-	-	-		
5/8/20	232	Air	75 L	25	Unit 232 – Living Room – Ambient (75 liters)		5-7	<1	<1	-	-	.	
5/8/20	232	Tape	-	23	Phase II Unit 232 – Painted Dry Wall near sprinkler		-	5-10	-	-	-		
5/8/20	232	Tape	-	24	Unit 232 Inside Plenum		5 S	1-2	5-10	-	-		
5/8/20	315	Tape	-	17	Unit 315 – Bathroom Closet – Door Trim		1 S	2-3	5-8	-	-		
5/8/20	336	Tape	-	30	Unit 336 – Living Room - window trim		4-6	2-3	3-5	-	-		
5/8/20	344	Tape	-	32	Unit 344 – Master Bed - Window sill		1-2	5-7	7-12	-	-		
1/9/19	408	Air	30 L	8	Phase (Bldg.) #1 Unit 408 kitchen/main	Moderate trace	1	-	-	4-5	-		
5/8/20	417	Air	75 L	18	Unit 417 – Loft – Ambient (75 liters)		10	2	5	-	-		
1/28/20	422	Bulk	-	47B	Unit 422 Bulk closet sheetrock sample		5-10	5-10	-	-	-		
3/25/20	427	Bulk	-	11	Unit 427 Bedroom window sheathing		1-15	-	-	-	-	Spotty for both fungal growth and	
1/9/19	430	Air	30 L	15	Unit 430 kitchen/main area	Moderate trace	6-7	1-2	3-4	-	-		Possible cooking-related residues
1/9/19	435	Air	30 L	17	Unit 435 kitchen/main area	Moderate trace	6-7	1-2	<1	-	-		
7/16/20	437	Air	2 min	27A	Unit 437 Common area	Moderate	7-8	<0.5	-	-	-		
5/8/20	445	Air	75 L	53	Phase III – Unit 445 (75 liters)		5-7	<1	<1	-	-	Asp/Pen ++	Unknown location
5/8/20	446	Tape	-	54	Phase III – Unit 446 – Bedroom window		4-8	1-2	1-3	-	-	Fungal +	
5/8/20	450	Tape	-	57	Phase III – Unit 450 – Master bedroom Light switch box		4-10	1	2-5	-	-	Fungal +++	
5/8/20	451	Tape	-	58	Phase III Unit 451 – Master Bath stud wall		5-10	2-3	-	-	-	Asp/pen like ++	
1/9/19		Air	30 L	16	Corridor outside Unit 430	Moderate trace	8-9	-	<1	-	-		
1/9/19		Air	30 L	18	Corridor outside Unit 434	Light trace	4-5	<0.5	<1	-	-		
4/8/20		Air	2 min	4A	Elevator #1 Floor 4 2 min.	Moderate 792	5-10	-	-	-	-	*The char shape was irregular	
5/8/20		Air	75 L	1	Phase I – Lobby - Ambient (75 liters)	Light trace	4-5	<0.5	<0.5	-	-		
5/8/20		Air	75 L	28	Phase II – North Hallway 3rd floor near		10	2-4	1-2	-	-	Fungal spores Asp/Pen ++	
5/8/20		Air	75 L	49	Phase I – Roof – Inside A/C Unit housing of 118 or 218 (75 liters)		6	<0.5	-	-	-	Fungal ++++	
5/8/20		Air	75 L	72	Phase I Cavity below ground floor – Garage elevator (75 liters)		8-9	2-3	-	-	-		Unknown location
5/8/20		Tape	-	8	2nd Floor Hall – North Painted Drywall		-	3-10	-	-	-		Unknown location
5/8/20		Tape	-	50	Phase II – Roof – A/C cover of Unit 437 or 337		1 S	5-10	-	-	-	Fungal ++++ Spotty soot	
5/8/20		Tape	-	51	Phase III – E-W Hallway – A/C unit by Unit 447		3-8	2-5	-	-	-	Fungal ++++	
5/8/20		Tape	-	63	Phase IV – Mechanical Closet outlet box		5-10	2	-	-	-	Aspergillus ++++	Unknown location
7/16/20		Air	2 min	1A	parking ramp Under tarps storing for 5th floor cabinets	Moderate to heavy	8-10	<1	-	-	-	Cladosporium spp. ++ Epicoccum spp. + Other fungal + Pollen +	
7/16/20		Air	2 min	4A	parking ramp 4th floor storage container #404	Moderate to heavy	8	<0.5	-	-	-	Fungal +	
7/16/20		Air	2 min	7A	parking ramp 4th floor inside storage Unit 466	Moderate	5	<0.5	-	-	-	Fungal +	
7/16/20		Air	2 min	8A	parking ramp Storage Unit 416	Moderate	5	<1	-	-	-	Fungal +	
7/16/20		Air	2 min	16A	parking ramp unit 321	Moderate	7	<0.5	-	-	-	Fungal +	
7/16/20		Tape	-	15T	parking ramp #303 third floor		4-6	<1	-	-	-		

Table 7. Samples analyzed by NG Carlson with high likelihood of combustion residues. Unit indicates sample taken inside unit number shown.

Inside	Date	Inside Unit	Type	Vol	ID-Carlson	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Notes	Additional notes
Int	5/8/20	137	Tape	-	39	Unit 137 – Interior Wall Framing		10-12	-	-	-	-	Very heavy debris	
Int	5/8/20	219	Air	75 L	9	Unit 219 – Bedroom 1 – Ambient (75 liters)	Moderate Trace	12-15	1-2	1	-	-		
Int	5/8/20	219	Tape	-	12	Unit 219 – Bedroom 3 – Painted Drywall		-	30-40	-	-	-		
Int	8/25/20	303	Tape	-	24T	Unit 303 Mechanical room		-	20-30	-	-	-	Particles similar to soot	Possible identification error
Int	1/28/20	307	Tape	-	69T	Unit 307 Bedroom 2 N. wall existing		-	30-40	-	-	-	Could be paint but particles are not all spheres	Possible identification error
Int	5/8/20	315	Air	75 L	15	Phase I – Unit 315 – Bedroom – Ambient (75 liters)	Light Trace	12-15	2-3	4-6	-	-		
Int	5/8/20	336	Air	75 L	29	Unit 336 – kitchen Island – Ambient (75 liters)	Very Heavy	45-50	5-8	1-2	-	-		
Int	5/8/20	344	Air	75 L	31	Phase II – Unit 344 – Bedroom 2 – Ambient (75 liters)	Very Heavy	25	10	-	-	-	Numbers are estimated as particle trace was very heavy	
Int	5/8/20	344	Tape	-	33	Unit 344 – Guest Closet - Baseboard		1-2	10-15	25-30	-	-		
Int	1/9/19	416	Air	30 L	6	Phase (Bldg.) #1 Unit 416 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-	The carbon black/soot particles had characteristics of both soot and carbon black- loose sphere clusters of soot- like particles.	Possible cooking-related residues
Int	1/9/19	422	Air	30 L	10	Unit 422 kitchen/main area	Moderate to Heavy Trace	<1	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	423	Air	30 L	11	Unit 423 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	426	Air	30 L	13	Unit 426 kitchen/main area	Moderate trace	<1	-	-	50+	-		Possible cooking-related residues
Int	1/9/19	428	Air	30 L	14	Unit 428 kitchen/main area	Moderate trace	<1	-	-	14-16	-		Possible cooking-related residues
Int	7/16/20	437	Tape	-	28T	Unit 437 Common area close to utility closet stud		5-15	-	-	-	-	Fungal +	
Int	5/8/20	438	Air	30 L	34	Phase II – Unit 438 – Living Room Circuit Box		3	15-20	-	-	-		
Int	5/8/20	438	Tape	-	35	Unit 438 – Living Room – Painted Dry wall		<1	10-12	1-2	-	-		
Int	7/16/20	441	Tape	-	19T	Unit 441 Bathroom north stud in nook		40 -50	-	-	-	-		
Int	5/8/20	447	Tape	-	52	Phase III – Unit 447 – Master Bedroom Door header		7-15	2-5	3-5	-	-	Fungal +++	
Int	5/8/20	452	Tape	-	59	Phase III Unit 452 – Living Room Window frame		2-4	1	10-20	-	-	Fungal +	
Int	5/8/20	456	Tape	-	67	Phase IV – Unit 456 – Bathroom Door Frame		15	1-2	-	-	-	Asp/Pen ++++ Alternaria spp. +	
Int	5/8/20	457	Tape	-	66	Phase IV – Unit 457 – sub floor truss in Living room		8-15	1-3	-	-	-	Asp/Pen ++++ Other fungal ++++	
	1/9/19		Air	30 L	7	Phase (Bldg.) #1 corridor in Bldg. #1 outside Unit 416	Moderate to Heavy Trace	<1	-	-	50+	-		
	1/9/19		Air	30 L	12	East corridor outside Unit 424	Moderate trace	-	-	-	50+	-		
	5/8/20		Air	30 L	48	Phase IV – S. Exterior Wall – Exhaust Vent Duct		10-15	-	-	-	-	Pine Pollen	Unknown location
	5/8/20		Tape	-	14	Phase I – Floor 2 Mechanical Room – Painted Drywall		-	30-40	-	-	-		Unknown location
	5/8/20		Tape	-	27	Phase II – North Hallway outside Unit 240 – Wood ceiling joist		10-20	1-2	-	-	-	Heavy Debris	
	5/8/20		Tape	-	42	Phase I – E. Exterior wall – behind siding		-	15-20	-	-	-	.	Unknown location
	5/8/20		Tape	-	46	Phase I – E. Exterior wall – Large vent duct (same as #45)		20-25	1-3	1-3	-	-	Heavy pollen and pine pollen	Unknown location
	5/8/20		Tape	-	47	Phase I – E. Exterior wall – Exhaust vent duct		3-8	1-3	10-20	-	-	Fungal ++ Heavy pollen and pine pollen	Unknown location
	5/8/20		Tape	-	60	Phase III – In-ceiling A/C Duct (top) outside Unit 445		8-12	1-2	2-5	-	-	Fungal +++	
	5/8/20		Tape	-	65	Phase IV – Top of A/C Unit in N-S Hallway		1-3	15-20	-	-	-	Asp/Pen ++++ Stachybotrys + Other fungal growth	Micrograph says: very spotty on this sample; Unknown location
	7/16/20		Air	2 min	11A	parking ramp 401-433 appliance storage	Heavy	40-50	<1	-	-	-	Fungal + Char and other char-like particles	
	7/16/20		Air	2 min	14A	parking ramp #303 third floor	Heavy	40-50	1-2	-	-	-	Fungal +	
	7/16/20		Air	2 min	1A	parking Outdoor air sample	Heavy	10-15	<1	-	-	-	Other fungal +	
	7/16/20		Tape	-	2T	parking ramp #119 pile on 5th floor		20-25	1-2	-	-	-	Pollen ++	Unknown location
	7/16/20		Tape	-	13T	parking ramp Open air garage sinks		15-20	1-2	-	-	-		
	7/16/20		Tape	-	3T	NW corner hallway North of Unit 144 Face of stud		5-15	<1	-	-	-	Fungal +	
	7/16/20		Tape	-	15T	Corridor outside Unit 442 OSB sheathing facing parking ramp		20-50	-	-	-	-		
	8/27/20		Air	2 min	P	Corridor Fire equipment area by Unit 236	Heavy	20-25	-	-	-	-	Fungal ++ Sample looks like outside air Atypical char particles	Stated to be atypical char; uncertain; no micrograph; discounted

To aid interpretation, samples analyzed by NG Carlson Associates that indicated moderate or high likelihood of combustion residues in Metropolitan housing units were mapped by floor level and unit (Figures 6 to 9). Each map shows three quantities: the number of samples in a housing unit with moderate likelihood of combustion residues (orange background); the number of samples in a unit with high likelihood of combustion residues (red background), and the total number of samples collected in the housing unit (blue background). This analysis includes 332 samples analyzed by Carlson (including air, tape or bulk) that were collected in units that could be identified. One sample, apparently mistakenly labeled as "unit 38," could not be located based on the available documentation. Samples taken in the parking area or in corridors were not included.

- Floor 1: Figure 6 shows that of the 48 samples collected, 2 samples (4%) indicated high likelihood of combustion residues. These were both tape samples on framing in Unit 137 and "hallway north of 144".
- Floor 2: Figure 7 shows that of the 55 samples collected, 4 (7%) and 2 (4%) of the samples indicated medium and high likelihood, respectively, of combustion residues. Three of the moderate likelihood samples were identified in Unit 232 (one inside a plenum); the high likelihood samples (tape and air) were identified in Unit 219, which is flagged with a star in the figure. Designating Unit 219 as showing high likelihood of combustion residues due to soot detected on a painted drywall in a bedroom is uncertain given that this unit had been occupied and that drywall removal in this building had started months earlier, thus, the soot detected appears likely to reflect resuspended material. The lack of documentation regarding the sample location and other matters makes this determination uncertain, but likely not to be representative of conditions in this unit or building, which is reinforced since no other samples in Phase 1-3 buildings were shown to have high likelihood samples (after correcting for likely sampling errors).

  Floor 3: Figure 8 shows that of the 81 samples collected, 4 (5%) and 6 (7%) indicated moderate and high likelihood, respectively, of combustion residues. In three of the "high" samples, laboratory notes raise questions regarding identification (i.e., possible paint particles rather than fire-related residues in Unit 307 (tape sample in a bedroom); "soot like" characteristics for a tape sample in the Unit 303 "mechanical room"; and uncertain counts in 344, a 75 L air sample in a bedroom. A medium likelihood (only) air sample was indicated in Unit 342. The remaining high (and in one case a moderate) likelihood samples were found in three units (315, 336, 344). In Unit 315, a 75 L air sample collected in a bedroom showed a high likelihood of combustion residues, however, air samples likely reflect contemporary sources of particles, e.g., cooking, outdoor pollutants, etc., and not fire-related combustion residues unless materials were disturbed. Further, this is the only sample of 8 samples were collected in Unit 315 that showed high likelihood of combustion residues; a tape sample in a bathroom closet trim in Unit 315 showed moderate likelihood of combustion residues; these levels were borderline (4-6). In Unit 336, the "high" sample was a 75 L air were collected on a kitchen island that may be cooking residues. In Unit 344, in addition to the "high" air sample noted above, a tape sample on the "master bed window sill" showed a moderate likelihood of combustion residues, and a "high" tape sample was collected on a "guest closet baseboard." The high tape sample was collected on May 8, 2020 on a baseboard, which would have been constructed after the fire, and thus this sample does not appear to represent fire-related combustion residues.
- Floor 4: Figure 9 shows that of the 147 samples collected, 11 (8%) and 13 (7.5%) samples indicated moderate and high likelihood, respectively, of combustion residues. High likelihood samples were shown in in 11 housing units. Six of the "high" samples were air samples, five of which were likely to reflect cooking-related residues, especially as carbon black and minimal char was detected and these units had been previously occupied. This applies to Units 416, 422, 423, 426 and 428. The sixth "high" air sample was in a "circuit box" in Unit 438 (an unusual place to collect a 30 L air sample, which would be likely to disturb the space). Of the "high" tape samples, two were collected on studs or trusses and not inhabited spaces (Units 441, 457). A "high" but marginal (5-15) tape sample was collected in Unit 437 ("common area close to a utility closet stud"). "High" tape samples were collected in Unit 438 ("painted dry wall"), 447 ("door header"), 452 ("window frame"), and 456 ("door frame"). Sampling in unit 438 on the painted dry wall surface (collected on May 8, 2020), indicates that the sample was collected on a building surface

installed well after the fire, and thus does not reflect fire-related combustion materials. Assuming the other tape samples were collected on surfaces exposed during or shortly after the fire, five units had high likelihood of combustion residues (shown with stars in Figure 8); three of these units are in the Phase 6 building.

Figure 6. 1st floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue.

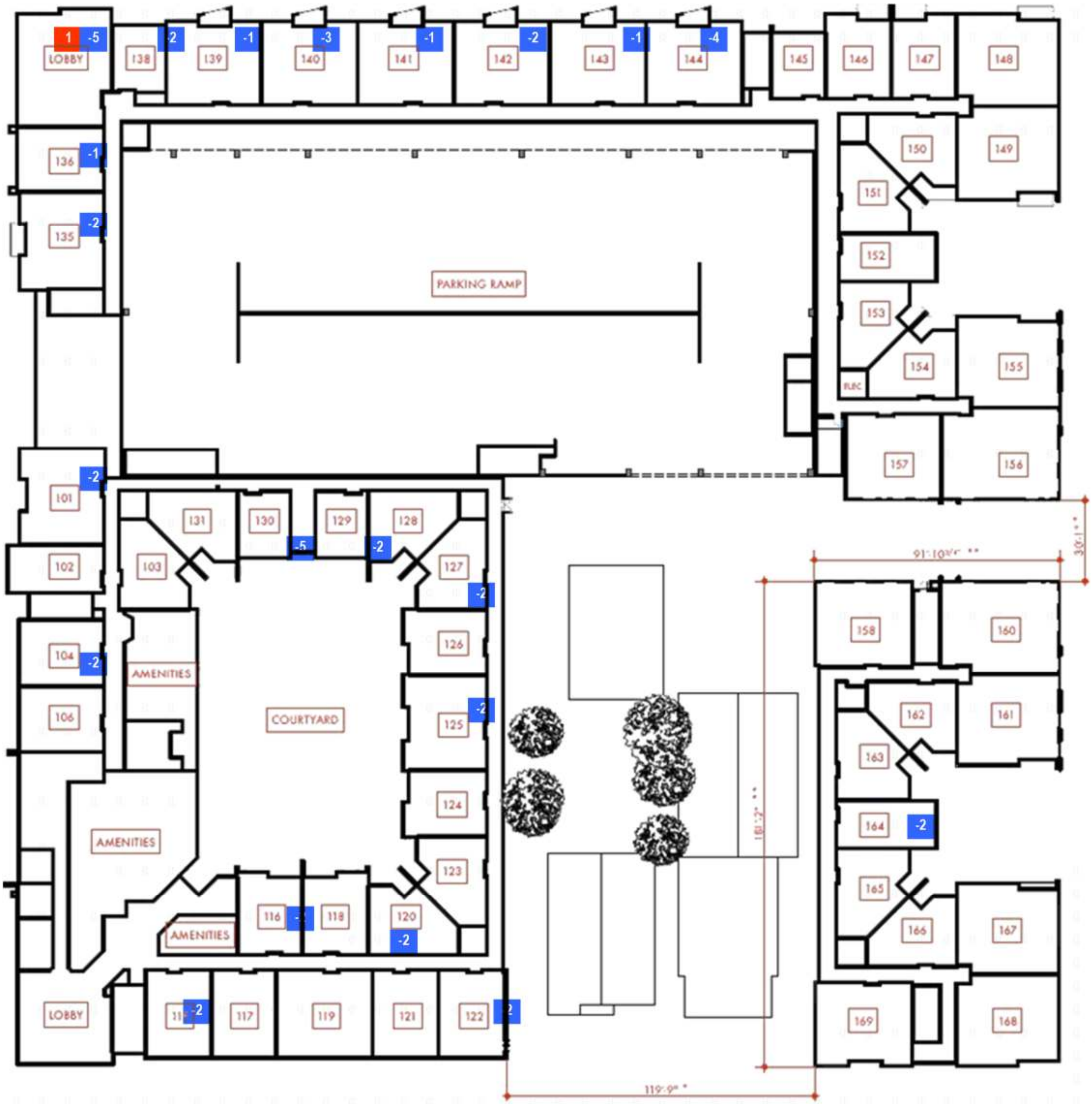

Figure 7. 2nd floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues, although this result appears uncertain and not representative.

Figure 8. 3rd floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues.

Figure 9. 4th floor plan of Metropolitan showing FBS results analyzed by NG Carlson with medium (yellow) and high (red) likelihood of combustion residues in Metropolitan apartments. Number of samples collected in each unit shown in blue. Star indicates unit where sampling suggests high probability of combustion residues.

6.3 Summary

Considering all of the samples collected by FBS and accounting for data quality issues, background or reference levels, and other factors normally considered in assessing environmental sampling results, a low percentage of samples showed either moderate or high likelihood of fire-related combustion residues in occupied spaces of the Metropolitan. Most samples showed normal or background levels. Most (6 of 7) of the units considered to have high likelihood of fire-related combustion residues in occupied spaces were found in or adjacent to the Phase 5 building, and on upper floors. The high likelihood sample in Unit 219 is anomalous and likely reflects resuspended material that is not representative. This analysis shows limited distribution of fire-related combustion residues in the Metropolitan: the vast majority of samples were negative. The identification of fire combustion residues in these locations is fully consistent with the meteorological data and analysis in Section 4. While a small number of samples showed combustion residues, this does not imply a health risks, as discussed next.

7 Health risks

Fire-related emissions and combustion residues likely to affect indoor environments and cause adverse health effects will have one or more of the following characteristics: high emission rates, high toxicity, environmental persistence, the potential to participate in sink/source relationships, and ability to expose individuals by a completed *source-to-receptor exposure pathway* involving human uptake, e.g., by inhalation. This section reviews the composition of emissions from fires, the toxicity of specific chemicals, and exposures in buildings, and determination of health risks.

7.1 Composition of fire-related emissions and combustion residues

7.1.1 Structure fires

The potential that combustion residues cause adverse health effects starts with the chemical and physical nature of fire-related emissions. The literature regarding the chemical composition of emissions from structure fires is limited and difficult to generalize since emissions depend on many factors, e.g., the burning rate, the material being burned, and fire conditions.[46] Environmental health concerns from urban fires during the fire and their aftermath focus on particulate matter, irritant gases (hydrogen chloride, sulfur dioxide, hydrogen fluoride, hydrogen bromide, nitrogen oxides, and ammonia), asphyxiant gases (carbon monoxide, hydrogen cyanide), organic toxicants (formaldehyde, formalin, PAHs, dioxins), ozone, and combustion-produced free radicals.[47] Depending on the material burned in structure fires, ash and debris produced by the combustion of building materials can contain lead, arsenic, hexavalent chromium, PAHs, dioxins, pesticides, and cresols.[48] Many fire-related emissions and combustion residues, including PAHs, are general indicators of incomplete combustion, and these compounds have numerous indoor and outdoor sources, e.g., cigarette smoke, asphalt pavement sealers, cooking (e.g., barbequing, frying and grilling), candles, gas combustion appliances, vehicle exhaust (especially diesel engines), leaf burning, and industry.[49]

Emission factors provide quantitative descriptions of the composition and emission rates of chemical including toxic compounds. The literature pertaining to emission factors from structure or urban fires is limited. Chemical

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[46] Stec, A, R. Hull, Fire Toxicity, Woodhead Pub, 2010.

[47] AIHA 2018, ibid

[48] Delia, A, D Baxter, The ABCs of Wildfire Residue Contamination Testing, *The Synergist*, 2017

[49] World Health Organization, Polycyclic aromatic hydrocarbons Guidelines for Indoor Air Quality: Selected Pollutants. 2010.

analyses conducted on a subset of samples collected at the Metropolitan were limited to elemental analyses intended to aid particle identification, and did not provide information pertaining to toxicity. For this reason, emissions information from better characterized wild land fires is reviewed.

7.1.2 Wild land fires

The literature pertaining to emissions from wild land fires is relatively large and growing. There are similarities and differences between the composition of structure and wild land fire emissions. The following underscores some of the characteristics of fires and present emission factors that describe the levels of toxic compounds, specifically PAHs, which is relevant to structure fires.

The composition of forest fire emissions has been reviewed by Urbanski,[50] Urbanski,[51] Yokelson,[52] Battye (for US EPA),[53] Durán,[54] and Akagi.[55] Conditions at such fires are complex and time varying, and include combinations of different thermal degradation processes (distillation, pyrolysis, char oxidation, flaming oxidation), a variety of material burned (wood types, soils, etc.), and a range of environmental conditions; these and other factors produces a wide range of gaseous and particulate emissions. Urbanksi (2009) notes that the major emissions include CO_2, CO, $PM_{2.5}$, and CH_4; other emissions include alkanes, alkenes, alkynes, aromatic hydrocarbons, aldehydes, ketones, alcohols (methanol), acids (formic and acetic), and furans. Oxygenated VOC emissions are dominated by methanol, acetic acid, formic acid, and formaldehyde. Additional emissions include PAHs, metals, chlorinated VOCs, and oxygenated and nitrogenated PAHs.

Emission factors from forest fires and other types of fires have been determined for a number of pollutants that allow estimates of both the amount and composition of fire emissions, including various gases, particulate matter, and PAHs. Benzo(a)pyrene (BaP) and certain other PAHs represent toxic and relatively persistent chemicals emitted in fires that can undergo off-gassing (volatilization) after being deposited on building surfaces as combustion residues. Among the PAH compounds, benzo(a)pyrene (BaP) is the most toxic chemical and one of the most abundant in combustion emissions. BaP constitutes from approximately 0.004 to 0.04% (by weight) in

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50 Urbanski, Shawn P., Wei Min Hao and Steve Baker, "Chemical Composition of Wildland Fire Emissions," *Developments in Environmental Science*, Vol 8, A. Bytnerowicz ed. Elsevier, 2009. 31.p. Accessed https://www.nifc.gov/smoke/documents/Chem_Comp_Wildland_Fire_Emissions.pdf

51 Urbanski, Shawn, Wildland fire emissions, carbon, and climate: Emission factors, *Forest Ecology and Management*, 317 (2014) 51–60, 2013.

52 Yokelson, R.J., Burling, I.R., Gilman, J.B., Warneke, C., Stockwell, C.E., de Gouw, J., Akagi, S.K., Urbanski, S.P., Veres, P., Roberts, J.M., Kuster, W.C., Reardon, J., Griffith, D.W.T., Johnson, T.J., Hosseini, S., Miller, J.W., Cocker III, D.R., Jung, H., Weise, D.R., 2013. Coupling field and laboratory measurements to estimate the emission factors of identified and unidentified trace gases for prescribed fires. *Atmos. Chem. Phys*. 13, 89–116. Also see supplemental materials.

53 Battye, William, Rebecca Battye, "Development of Emissions Inventory Methods for Wildland Fire, EC/R Inc. Feb. 2002. https://www3.epa.gov/ttnchie1/ap42/ch13/related/firerept.pdf

54 Durán, Sandra. Evidence Review: Wildfire smoke and public health risk, British Columbia (Canada) Center for Disease Control. March 31, 2014.

55 Akagi, S. K; Yokelson, R. J; Wiedinmyer, C; Alvarado, M. J; Reid, J. S; et al. Emission factors for open and domestic biomass burning for use in atmospheric models. *Atmospheric Chemistry and Physics*;.11, 9, 2011: 4039.

particles emitted from forest fires for particles up to about 10 μm diameter, a size range that contains most of the PAHs.[56] [57]

7.2 Toxicity and health risks of combustion residues

The toxicity of exposure to many fire-related pollutants, such as particulate matter, carbon monoxide, and many other pollutants is well known, and there is a voluminous literature on many pollutants. This applies to direct inhalation exposure, typically during the active burning phase, which is most relevant to fire fighters, other first responders, and general populations that may be exposed. These are mostly acute or short-lived exposures (minutes to a few days), and generally not relevant to deposited or settled combustion residues.

Fire-related emissions and combustion residues concerns raised at the Metropolitan include PAHs. As noted earlier, sources of PAHs are numerous and exposure is ubiquitous. PAHs are products of incomplete combustion, and common sources include tobacco smoke, wood smoke, fireplaces, cooking, candles, combustion of natural gas, many industrial process, traffic and engine exhaust. PAHs comprise a large and diverse set of compounds. Some PAHs are toxic and thus of health concern. PAHs also serve as *indicators* of other compounds that might be present and associated with fire-related emissions or combustion residues that may not be measured. This indicator role is important since it is not feasible (or possible) to measure each pollutant that might be present. Some PAH compounds are persistent, some may off-gas, and some are toxic at low concentrations. The major health concern with PAHs is *chronic exposure* (long term) that can increase the risk of cancer. Two PAHs (benz[a]anthracene and benzo[a]pyrene) are considered as probable human carcinogens, and four other PAHs (benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-c,d]pyrene) as possible carcinogens.[58,59]

Reference levels have been determined for many toxic chemicals, based on toxicological, epidemiological and modeled data, and represent concentrations that individuals may be exposed to that present a minimal, and generally negligible, likelihood of an adverse health outcome. Information pertaining to PAHs for which US Environmental Protection Agency (among others) has recommended guidelines is shown in Table 8. These are taken from the comprehensive set of reference levels called the *Regional Screening Levels* (RSLs). While initially developed for application at Superfund sites, RSLs represent updated and consistent comparison values for residential air (also commercial/industrial exposures to soil, air, and drinking water). For a given chemical, the RSL is a concentration that corresponds to fixed a level of risk, either a one-in-one million for cancer risk, which is defined as developing a tumor over an individual's lifetime due to exposure, or a noncarcinogenic hazard quotient of 1, which is the level at which no adverse non-cancer effects are expected from acute or chronic

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56 The proportion of PAHs emitted from a fire was calculated as the ratio of the emission factors (EF) for PAHs and $PM_{2.5}$. The PAH considered was benzo(a)pyrene (BaP), considered the most toxic PAH. The EF for BaP ranges from 0.004 mg/kg wood burned (Battye, 2002) to 4.9 mg/kg (Kakreka average in WHO, 2011). The EF for $PM_{2.5}$ ranges from 7 to 15 g/kg of wood burned, depending on the forest type (Akagi et al. 2011); the average 11 g/kg was used. The BaP fraction in small particles is thus 0.0004 to 0.045% of $PM_{2.5}$ by weight, i.e., on the order of 1 part in 2200 to 1 part in 27000. This estimate applies to BaP and is an order of magnitude estimate given the many factors that can affect emissions. Very similar estimates are obtained in the citation in the next footnote.

57 A separate estimate from a different source for the BaP percentage in wood combustion is 0.0285% in PM_{10}. From Khalili, Asrin R., Peter A. Scheff, Thomas M. Holsenpah. Source fingerprints for coke ovens, diesel and gasoline engines, highway tunnels, and wood combustion emissions. *Atmospheric Environment* 29. 4, 533-542, 1995

58 Agency for Toxic Substances and Disease Registry, Public Health Statement for Polycyclic Aromatic Hydrocarbons (PAHs), 1995. https://www.atsdr.cdc.gov/PHS/PHS.asp?id=120&tid=25. Accessed 5-20-19.

59 WHO, Chapter 6, Polycyclic aromatic hydrocarbons: Guidelines for Indoor Air Quality: Selected Pollutants, Geneva: World Health Organization; 2010. ISBN-13: 978-92-890-0213-4. https://www.ncbi.nlm.nih.gov/books/NBK138705/

exposures.[60] For many chemicals, the RSLs are similar or identical to other screening levels used by other agencies,[61] although a number of states consider higher risks to be acceptable, e.g., 1 in 100,000, which would have the effect of multiplying the screening level in the table below by 10. The key factor in this table is the Screening Level for benzo(a)pyrene, the most toxic PAH, which has the lowest screening level, 0.002 µg/m^3. Maintaining average levels below this value is considered safe.

There can be considerable uncertainty in setting reference levels, and differences of approximately a factor of 2 to 10 in reference levels are not unexpected and may not be meaningful. Reference levels are designed to be conservative and health protective, and they incorporate uncertainty using safety factors and confidence intervals. Thus, even concentrations that approach or exceed risk-based screening levels are not necessarily harmful or unsafe.

Table 8. Toxicity information for PAHs that have risk-based health protective levels. The screening level is the recommended concentration limit from US EPA for residential exposure using 1 in a million cancer risk and hazard ratio of 1.[62] WOE is weight of evidence classification.

		Non-cancer Effects		Cancer Effects				
Name	**Screening Level** (ug/m3)	**Effects**	**Ref**	**EPA WOE**	**IARC WOE**	**Risk Factor** (m3/ug)	**Effects**	**Reference**
Naphthalene	0.083	Methemoglobinemia, chronic nasal inflammation, olfactory epithelial metaplasia, and respiratory epithelial hyperplasia.	OEHHA (2005)	C	2B	3.4E-05	Respiratory epithelial adenoma, olfactory epithelial neuroblastoma	OEHHA (2005)
Chrysene	1.700		IRIS (1990f)	B2	2B	6.0E-07	Liver tumors, malignant lymphoma, hepatic tumors and lung tumors	IRIS (1990f)
Benzo(a)anthracene	0.017		IRIS (1990g)	B2	2B	6.0E-05	Pulmonary adenoma, hepatoma and liver adenomas	IRIS (1990g)
Benzo[b]fluoranthene	0.017		IRIS (1990h)	B2	2B	6.0E-05	Liver adenomas and hepatomas, lung adenomas	IRIS (1990h)
Benzo[k]fluoranthene	0.170		IRIS (1990i)	B2	2B	6.0E-06	Hepatic adenomas and hepatomas, lung adenomas	IRIS (1990i)
Benzo[a]pyrene	0.002	Developmental, immunological and reproductive effects	IRIS (2017)	CH	1	6.0E-04	Forestomach, liver, oral cavity, duodenum, and auditory canal tumors	IRIS (2017)
Indeno[1,2,3-cd]pyrene	0.017			B2	2B	6.0E-05	Tumors and gene mutation	IRIS (1990j)
Dibenz[a,h]anthracene	0.002			B2	2A	6.0E-04	Carcinomas, DNA damage and gene mutations	IRIS (1990k)
Dibenzo[a,e]pyrene	0.003			-	3	6.0E-04	Carcinoma, papilloma, sarcoma, skin neoplasms	NCBI (2020c)

60 United States Environmental Protection Agency (EPA) Regional Screening Levels (RSLs) 2018 EPA RSL noncarcinogenic values. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

61 For example, many RSLs are similar or identical to levels in EPA's Risk Information System (https://www.epa.gov/iris), and also similar or identical to levels for Michigan's risk screening levels (http://www.deq.state.mi.us/itslirsl/results.asp).

62 The Regional Screening Levels are available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. IRIS is the US EPA Integrated Risk Information System. OEHHA is the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA).

7.3 Exposure and risk

7.3.1 Exposure and risk assessment

Toxic chemicals like PAHs are common or ubiquitous in indoor and outdoor settings and everyday life. However, chemicals found at low levels and those with minimal potential for exposure and human intake (called *dose*) do not pose a health concern. While the old adage *the dose makes the poison* [63] is simplistic, it conveys the importance of quantifying the exposure. *Quantitative risk assessment* is used to allow meaningful assessments of chemical risks and to guide subsequent risk management actions to protect individuals and public health, and to avoid needless actions to address so-called phantom risks.

Quantitative risk assessments and management actions follow well-defined steps to provide objective assessments that are protective of public health. The practice of risk assessment and management include quantification of the likelihood or probability of harm to determine whether a risk is acceptable or requires mitigation. This applies to short-term or *acute* exposures of toxicants causing non-cancer health endpoints like carbon monoxide, which have threshold-limited dose-response relationship. It also applies to long-term or *chronic* exposures of toxicants like PAHs that can cause cancer, and which have a continuous, zero threshold dose-response relationship describing the likelihood of an adverse health impact. For chemicals causing cancer, assessments are mostly based on the likelihood of causing a tumor over the lifetime. Only a very small likelihood is considered to be acceptable for environmental contaminants. These likelihoods are limited to a probability or chance of 1 in 10,000 (10^{-4} risk) to 1 in 1 million (10^{-6} risk).

As a simple and protective approach that follows from the risk levels just above, measured or estimated concentrations are compared to guideline or reference levels. The EPA RSLs (Table 8) are relevant for residential exposure, are protective, relevant to both acute and chronic exposure, and consider both cancer and non-cancer endpoints. Maintaining average levels below the reference level is considered safe for human exposure.

7.3.2 Exposure pathways

Individuals may be exposed to combustion residues if these residues or components thereof make their way into the occupied living spaces and are inhaled. In cases, chemicals may migrate to surfaces, dusts, foods, or other materials that are subsequently ingested. For exposure to represent a health risk, concentrations must exceed reference levels. For carcinogens, concentrations must exceed reference levels on a long-term basis, typically over many years.

Combustion residues that have been deposited or settled in building cavities or other hidden surfaces must have a completed source-receptor pathway, i.e., migrate to occupied living spaces, to exposure individuals. For low volatility chemicals in a building cavities, this migration can only occur in the event of a disturbance, most typically construction activities that open up the wall or other compartment. For semi-volatile chemicals (SVOCs) which include many PAHs, volatilization or off-gassing from building cavities, migration into indoor air, and subsequent deposition on particles or other surfaces is an additional pathway that potentially can expose individuals.

No gaseous or vapor phase sampling was conducted, and no chemical analyses were conducted relevant to off-gassing, thus there is no evidence of off-gassing of combustion residues. Similarly, no surface concentration measurements were made of chemicals like PAHs in the Metropolitan, thus there is no evidence of levels toxic chemicals on surfaces. As mentioned, there are numerous other indoor and outdoor sources of soot and PAHs; these substances are ubiquitous; and the contribution of fire-related combustion residues must account for the

[63] "The dose makes the poison" (Latin: sola dosis facit venenum 'only the dose makes the poison') is an adage intended to indicate a basic principle of toxicology. It is credited to Paracelsus who expressed the classic toxicology maxim "All things are poison, and nothing is without poison; the dosage alone makes it so a thing is not a poison." https://en.wikipedia.org/wiki/The_dose_makes_the_poison.

presence of normal background and environmental levels known to exist in Birmingham and essentially everywhere (Section 5.2.3).

Any off-gassed compounds from combustion residues in building cavities would be at very low airborne concentrations in the Metropolitan for several reasons: the limited extent of fire-related combustion residues in the buildings; the passage of time and normal air change in the building that would tend to degrade and flush out these chemicals from building air; the low to very low volatility of these chemicals, other chemical properties that produce very low emission rates and a tendency for deposition or binding to particles and surfaces with limited, if any vapor-phase fraction; and the limited air flow rates in building cavities that would transport these chemicals into the occupied space prior to redeposition.

The amount of soot needed as fire-related combustion residues in a typical housing unit at the Metropolitan to produce chronic exposures to BaP that would equal to the protective RSL was estimated using conservative and worst-case assumptions and the information pertaining to the Metropolitan's layout.[64] This analysis used a "worst-case" screening level estimate and a mass balance approach. While there are many simplifying assumptions, each goes in the conservative direction, e.g., it is assumed that all BaP in soot volatilizes, that no BaP degrades, that individuals never leave the housing unit, and that all BaP contributes to indoor levels. To achieve the RSL, which is considered a safe exposure, each residence unit must have from 83 to 3038 grams of soot as combustion residues, i.e., from about 3 ounces to 6 lbs. The amount of soot would completely coat some or all walls in each unit. While based on well-founded mass balance principles, this calculation is hypothetical, simplified and approximate. However, <u>the analysis demonstrates the considerable amount of soot needed to produce a health risk from off-gassing and migration from building cavities or other locations under highly</u>

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[64] The "worst-case" screening level calculation used a mass balance approach to demonstrate that the quantity of soot needed in each unit to produce the EPA risk-based Regional Screening Level. The assessment assumes the following: Soot contains BaP, the most toxic PAH, at levels from 0.0036 to 0.045% of soot by mass (as discussed previously). An indoor concentration equal to the health protective reference level (0.002 $\mu g/m^3$) is produced by soot volatilization and migration to the living space. All BaP in soot is assumed to be volatilized and migrate to living areas at a constant rate over the exposure period of 10 to 30 years. BaP does not degrade over this period. The volatilized BaP and PAHs are uniformly distributed in the living space. The exposed individual is in the building 24 hours a day for 365 days per year for the exposure period. (In reality, much of the BaP and PAHs would remain bound to surfaces and not migrate; BaP and PAHs could also migrate directly into outdoor air or non-living areas resulting in no exposure; oxidation and degradation would tend to reduce BaP and PAH levels over time; and individual will leave the Metropolitan for substantial portions of the day.) It is also assumed that the apartment volume averages 280 m^3, based on an area of 1100 SF and 9 ft ceiling height. (This is estimated from the architectural plan and is a non-critical assumption.) The air change rate for the apartment is assumed to average 0.75 hr^{-1}. (Most US homes have air change rates that range from about 0.5 to 1.0 hr^{-1}). Volatilized PAH are removed from the living space by the air flow determined by air change rate. With these assumptions, the amount of soot required in <u>each</u> unit to reach a chronic exposure of BaP at the reference level ranges from 83 to 3038 grams, i.e., from about 3 ounces to 6 lbs.

Expressed differently, if this soot resulted from air infiltration and particle penetration from an exterior wall (8.4 m^2 in area using the stated dimensions) where it was first deposited and the soot density was 1.5 g/cc, then the entire wall would be 100% coated with a thickness from about 10 to 400 µm of soot (depending on the assumptions above); if the soot came in as particles 1 µm in diameter was uniformly deposited, this would represent roughly 10 to 400 layers of soot particles, e.g., many layers of soot particles would cover the entire wall. While based on mass balance, these are hypothetical, simplified and approximate calculations intended only to demonstrate that the amount of soot needed to produce a health risk from off-gassing and migration from building cavities or other locations under highly conservative conditions.

The level of contamination from this calculation would be plainly visible. The FBS report (Oct. 5, 2020) asserts (p. 54): "None of the combustion byproducts sampled by FBS could be seen by the naked eye and that is what makes it so dangerous." This may be referring to individual soot particles.

conservative conditions, which far exceeds the actual amount of combustion residues in the Metropolitan, thus off-gassing is extremely unlikely to yield unsafe concentrations.

7.4 Concentrations of PAH and other compounds will decrease with time

PAHs and other organic chemicals degrade over time due to chemical reactions and chemical degradation. These reactions are facilitated by other chemicals, e.g., hydroxyl radicals and ozone, as well higher temperature. The lifetime of PAHs and other SVOCs in air and on indoor surfaces exposed to sunlight, ozone and hydroxyl radicals can be shortened considerably. Considering BaP, the most toxic PAH, the atmospheric lifetime in a typical urban atmosphere is only 20 minutes; a few or days hours might be expected in most atmospheres.[65] Reaction and degradation will lower emission rates from deposited or settled chemicals like PAHs, and will also lower concentrations of any fraction of the chemical that has volatilized, become airborne and migrated into the living space.

7.5 Literature evidence of exposure

The health effects of exposure to combustion residues like PAHs that may have infiltrated into a structure following a wildfire have not been well characterized in the literature.[66] However, a recent (2019) and comprehensive study of wild land and urban fringe fire-related residues in 64 homes exposed to the very large 2016 wild land-urban interface fires at Fort McMurray, Alberta Canada showed no evidence that forest fire ash remained in household 14 months after the fire, and overall house dust pollutant concentrations were equal or lower than in other locations unaffected by wildfires, suggesting negligible potential for long term effects in buildings from fire-related combustion residues.[67]

7.6 Omissions and flaws by FBS

The visual and/or microscopic detection of fire-related combustion residues in building cavities and interstitial spaces, or in building air and surfaces does not represent a health risk. Risk depends on establishing the presence of a toxic substance where individuals can be exposed, e.g., air inhaled by an individual, and determining that concentrations, exposure periods and uptake of the chemical are sufficiently high to obtain a meaning dose. FBS's statements regarding the detection of soot, ash and/or char provide little if any information regarding the physical or chemical composition or concentration of these materials. FBS presents no evidence regarding fire-related combustion residues that would affect air quality and exposure building occupants or cause health effects. Evidence of fire-related emissions is limited to observations of soot, ash and char particles on certain interior surfaces and in air samples. While even much this evidence is flawed or misinterpreted (Section 5.2), the levels of combustion residues are far below levels needed to produce any meaningful risk of a health effect. Thus, no evidence exists to support the conjecture pertaining to off-gassing or harmful levels of PAHs or other carcinogens due to fire-related combustion residues at the Metropolitan.[68]

FBS statements pertaining to the health risk of cancer from fire combustion residues represent phantom risks. The presence or suspicion of a carcinogen does not mean that an actual or imminent risk is present and unacceptable, and that mitigation, removal, building renovation or reconstruction is required. If so, modern

[65] Based on BaP's atmospheric hydroxylation rate (7.8E-11 cm^3/molecules-s) and typical urban OH concentrations (6E6 molecules/cm^3), most BaP will be degraded in 0.4 hours; considering lower and average tropospheric levels of OH (1.1 E5 cm^3/molecules-s), degradation will take 2.3 hours. Environmental properties from ToxCast, https://www.epa.gov/chemical-research/toxcast-chemicals

[66] AIHA 2018, ibid.

[67] Kohl, L. et al. Limited Retention of Wildfire-Derived PAHs and Trace Elements in Indoor Environments, *Geophysical Research Letters*, 46, 383-391.

[68] See footnote 41

commerce and countless human activities that use many of the tens of thousands of chemicals in commerce would cease in their present form.

7.7 Summary of health risks

There is no evidence that fire-related combustion residues at the Metropolitan would cause adverse effects, including chemicals that may migrate from residues settled or deposited in building cavities into occupied spaces. Screening level calculations and recent literature show that health risks are extremely unlikely and that indoor levels of many chemicals will decline over time. Even if significant smoke exposure had occurred, the use of appropriate cleaning and restoration practices would return the building to normal and safe conditions.

The evidence at the Metropolitan strongly suggests that common everyday sources of PAHs and other SVOCs, e.g., industrial and traffic-related pollutants, candles, cigarette smoke, cooking, gas combustion, etc., would far exceed levels that could be produced by off-gassing and/or migration of any combustion residues that might be present.

FBS did not obtain quantitative measurements of carcinogens or other toxic substances in their sampling. FBS did not conduct a quantitative risk assessment or use other objective method to assess possible health risks from fire residues at the Metropolitan. FBS expressed numerous statements that can be characterized as *phantom risks*, scientifically known as a false positive or type 1 error, that misrepresented risks.[69]

8 Cleaning and restoration

Post-fire cleaning and restoration guidance is well developed.[70] Practices include the use of dry or wet removal techniques, e.g., mopping, damp wiping, pressure washing, air scrubbing, and vacuuming using HEPA-filter equipment; removal and replacement of air filters; and immersion cleaning of absorbent materials, etc. Inspections and tests could be used to verify the effectiveness of cleaning/restoration, including showing negligible levels of hazardous chemicals. Standard cleaning and restoration practices at the Metropolitan would be expected to remove fire-related combustion residues and return conditions to normal levels that do not pose a health risk.

9 Conclusions

There is no evidence supporting significant infiltration, penetration or migration of smoke and combustion residues from the Phase 6 building fire into Phase 1-3 buildings, rather, the prevailing meteorology, building configurations, and other factors would limit smoke exposure and infiltration and particle penetration through the building envelope. Some samples in some areas of Phase 4 and 5 buildings had greater potential of smoke exposure from the fire, but the sampling data shows only limited areas with a high likelihood of combustion

[69] This is arguably the most basic type of statistical error. In elementary statistics, students learn to avoid these errors in hypothesis testing using the concept of a p-value.

[70] For example, see the following:

US EPA, Should You Have the Air Ducts in Your Home Cleaned? https://www.epa.gov/indoor-air-quality-iaq/should-you-have-air-ducts-your-home-cleaned

Institute of Inspection, Cleaning and Restoration Certification Standard

Restoration Industry Association, Guidelines for Fire and Smoke Damage Repair, 2nd edition. Washington, D.C. 2007.

National Air Duct Cleaners Association, Standard for Assessment, Cleaning, and Restoration, 2013.

residues, the pathway for entry of fire-related combustion residues was not completed, and thus the penetration and entry of fire-related combustion residues into the building is low or minimal. This is supported by the reanalysis of the FBS sampling data that showed normal levels of fire-related combustion residues in the vast majority of samples. Only a few areas had measurements that were considered to have a high likelihood of being fire-related combustion residues.

There is no evidence supporting that adverse health effects could be caused by combustion residues present in the Metropolitan. While soot, char and ash can contain chemicals that are considered carcinogenic, these compounds were not quantified; the evidence shows few locations where fire-related soot, char or ash was identified at high levels with high likelihood; the same applies for combustion residues in building cavities levels that also have low potential migration and human exposure. Conclusions drawn by FBS regarding widespread and serious contamination by fire-related combustion residues that will cause cancer are unfounded by the evidence and lack the essential foundations of exposure, dose, pathway, reference level, and risk quantitation to be scientifically credible.

The amount of PAHs in building cavities that is needed to present even a small health risk would exceed any level reported or inferred at the Metropolitan by orders of magnitude. Even where combustion residues are present, the governing physical/chemical mechanisms and recent literature indicate that the level of combustion residues will diminish over time and not pose meaningful risks of adverse health effects. Any off gassing of fire-related residues would decrease over time, and normal ventilation and air change in the Metropolitan would flush out and degrade any emissions that made it to occupied spaces.

Cleaning and restoration of smoke exposed portions of the building would have been sufficient to return the building to normal and safe conditions.

The testing data by FBS pertaining to fire-related combustion residues and other evidence discussed above provide no rationale for the full remediation the Phase 1-5 buildings.

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Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
8/25/20	Tape	-	Int	38	34T	Unit 38 Bedroom abutting kitchen to left of main door		<1	-	-	-	-		Is there unit 38? Appears incorrect labeling.
3/19/20	Air	5 min	Int	101	19A	Unit 101 Left room on cart	Light	<0.5	-	-	-	-	Fungal +	
3/19/20	Tape	-	Int	101	20T	Unit 101 Rt. Bathroom back side of metal box		-	-	-	-	-		
3/19/20	Air	5 min	Int	103	15A	Unit 103 Master closet on cart	Light to moderate	<0.5	<0.5	-	-	<1	Asp/pen (900/cu. meter)	
3/19/20	Bulk	-	Int	103	16B	Unit 103 Mechanical closet painted dry wall		-	-	-	-	-	Pollen	
3/19/20	Air	5 min	Int	104	17A	Unit 104 kitchen floor	Light to moderate	<0.5	-	-	-	1-2		
3/19/20	Tape	-	Int	104	18T	Unit 104 Bedroom ABS pipe		-	-	-	-	-		
3/19/20	Air	5 min	Int	115	1A	Unit 115 on cart	Light to moderate	<0.5	-	-	-	<1		
3/19/20	Tape	-	Int	115	2T	Unit 115 painted wall		<0.5	-	-	-	-		
3/19/20	Air	5 min	Int	116	3A	Unit 116 Bedroom floor	Light to moderate	<0.5	-	-	-	<0.5		
3/19/20	Tape	-	Int	116	4T	Unit 116 Interior wall stud		-	-	-	-	-		
3/19/20	Air	5 min	Int	120	5A	Unit 120 on cart	Light to moderate	<0.5	-	-	-	1-2	Fungal + Clad (200/cu. Meter) Asp/pen (1,600/cu. meter)	
3/19/20	Tape	-	Int	120	6T	Unit 120 Master closet wall stud		-	-	-	-	-		
3/19/20	Air	5 min	Int	122	7A	Unit 122 Kitchen floor	Light to moderate	<0.5	-	-	-	1	Fungal + Asp/pen (120/cu. meter)	
3/19/20	Tape	-	Int	122	8T	Unit 122 Painted wall		-	-	-	-	-		
3/19/20	Air	5 min	Int	125	9A	Unit 125 Rt. Bedroom on cart	Light to moderate	<0.5	-	-	-	<0.5	Fungal + Pine pollen	
3/19/20	Tape	-	Int	125	10T	Unit 125 Left room Exterior wall stud		-	-	-	-	-		
3/19/20	Air	5 min	Int	127	11A	Unit 127 Bathroom on cart	Light to moderate	<0.5	-	-	-	<0.5	Fungal + Mite +	
3/19/20	Tape	-	Int	127	12T	Unit 127 electric wire above breakers		-	-	-	-	-		
3/19/20	Air	5 min	Int	129	13A	Unit 129 Closet floor	Light	-	-	-	-	<0.5	Asp/pen (390/cu. meter)	
3/19/20	Tape	-	Int	129	14T	Unit 129 kitchen painted dry wall		-	-	-	-	-		
5/8/20	Air	75 L	Int	130	3	Phase I – Unit 130 – Ambient (75 liters)	Very Light trace	1-2	-	<0.5	-	-		
5/8/20	Air	75 L	Int	130	5	Unit 130 – West wall outlet	Moderate Trace	<1	-	<1	-	-		
5/8/20	Tape	-	Int	130	4	Unit 130– Baseboard		1 S	1-2	<1	-	-		
5/8/20	Bulk	-	Int	130	6	Unit 130 – Air Filter		<1	<1	-	-	-	Light Stachybotrys spp.	
5/8/20	Tape	-	Int	130	7	Unit 130 – Inside Plenum		3-4	1-2	1-2	-	-		
9/11/20	Tape	-	Int	135	12T	Unit 135 Sill plate bedroom		1-3	-	-	-	-	Paint particles Spotty char Fungal +	
9/11/20	Air	xx min	Int	135	11A	Unit 135 Batroom off bedroom right at main entrance	Heavy	-	<0.5	-	-	-	Paint particles	
9/11/20	Air	xx min		135	12A	Corrider Outside Unit 135	Very Heavy	-	-	-	-	-	Paint particles	
9/11/20	Tape	-	Int	136	11T	Unit 136 Windowsill living room		-	-	-	-	-		
5/8/20	Air	75 L	Int	137	38	Phase II – Unit 137 – Ambient (75 liters)		4	<0.5	-	-	-	Pine pollen	
5/8/20	Tape	-	Int	137	39	Unit 137 – Interior Wall Framing		10-12	-	-	-	-	Very heavy debris	
5/8/20	Bulk	-	Int	137	40	Unit 137 – West Exterior wall - Insulation		<0.5	-	-	-	-		
9/11/20	Tape	-	Int	137	10T	Unit 137 Living room patio door stud		-	-	-	-	-	Paint particles Fungal +	
9/11/20	Air	xx min	Int	137	10A	Unit 137 Batroom off bedroom right of main entrance	Heavy	-	<0.5	-	-	-	Paint particles	
9/11/20	Tape	-	Int	138	9T	Unit 138 Bathroom closet rear stud		-	-	-	-	-	Paint particles	
9/11/20	Air	xx min	Int	138	9A	Unit 138 Batroom right of main entrance	Heavy	<0.5	-	-	-	-	Paint particles Fungal +	
9/11/20	Tape	-	Int	139	8T	Unit 139 Bedroom exterior wall		1-2	-	-	-	-	Paint particles	
9/11/20	Tape	-	Int	140	7T	Unit 140 Exterior bedroom wall		-	-	-	-	-	Paint particles	
9/11/20	Air	xx min		140	6A	Corridor between Unit 140 and 141	Light to Moderate	<0.5	-	-	-	-		
9/11/20	Air	xx min	Int	140	7A	Unit 140 Mechanical room	Moderate	-	<0.5	-	-	-	Paint particles	

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
9/11/20	Air	xx min	Int	140	8A	Unit 140 Bedroom left of main entry door	Moderate	-	<1	-	-	-	Paint particles Fungal +	
9/11/20	Tape	-	Int	141	6T	Unit 141 Patio door stud pack		-	-	-	-	-	Paint particles	
9/11/20	Tape	-	Int	142	5T	Unit 142 Shower wall stud near floor		-	-	-	-	-	Paint particles	
9/11/20	Air	xx min	Int	142	5A	Unit 142 Main kitchen area by entry door	Moderate	<0.5	-	-	-	-	Paint particles	
9/11/20	Tape	-	Int	143	4T	Unit 143 Living room exterior stud		-	-	-	-	-	Paint particles	
7/16/20	Air	2 min		144	2A	NW corner hallway North of Unit 144	Moderate	1	-	-	-	-	Fungal +	
7/16/20	Tape	-	Int	144	**3T**	NW corner hallway North of Unit 144 Face of stud		5-15	<1	-	-	-	Fungal +	
9/11/20	Tape	-	Int	144	2T	Unit 144B Utility closet		-	-	-	-	-	Paint particles Fungal ++++	
9/11/20	Tape	-	Int	144	3T	Unit 144A Bathroom wall stud		-	-	-	-	-	Paint particles	
9/11/20	Air	xx min		144	2A	Stair tower by Unit 144	Light to Moderate	<0.5	<0.5	-	-	-		
9/11/20	Air	xx min		144	3A	Corridor by Unit 144	Light	<0.5	<0.5	-	-	-	Fungal +	
9/11/20	Air	xx min	Int	144	4A	Unit 144 Batroom left of main entry door	Light to Moderate	<0.5	-	-	-	-	Sheetrock dust	
3/11/20	Air	2 min	Int	203	34A	Unit 203 Bedroom off living room 2 min.	Moderate	<0.5	-	-	-	4		
3/11/20	Tape	-	Int	203	35T	Unit 203 Bedroom wall on existing gypsum wall		-	-	-	-	-		
3/11/20	Air	2 min	Int	209	33A	Unit 209 Bedroom 2 min.	Heavy	-	-	-	-	50+		
3/11/20	Air	2 min	Int	213	30A	Unit 213 Living room 2 min.	Very Light	-	-	-	-	-		
3/11/20	Tape	-	Int	213	31T	Unit 213 kitchen back splash		-	-	-	-	50+		
3/11/20	Tape	-	Int	213	32T	Unit 213 Bedroom exterior sheathing in bedroom near kitchen		-	-	-	-	-		
3/11/20	Air	2 min	Int	216	25A	corridor outside Unit 216 2 min.	Moderate to heavy	<0.5	-	-	-	50+		
3/11/20	Air	2 min	Int	216	27A	Unit 216 Bedroom 2 min.	Very Heavy	-	-	-	-	50+		
3/11/20	Tape	-	Int	216	26T	Corridor outside Unit 216 Back of gypsum on corridor of Unit 216		-	-	-	-	<0.5		
3/11/20	Tape	-	Int	216	28T	Unit 216 SMG on exterior OSB in bedroom (low)		-	<1	-	-	<1		
3/11/20	Tape	-	Int	216	29T	Unit 216 SMG on exterior OSB in bedroom (high)		-	-	-	-	-		
5/8/20	Air	75 L	Int	219	9	Unit 219 – Bedroom 1 – Ambient (75 liters)	Moderate Trace	12-15	1-2	1	-	-		
5/8/20	Air	75 L	Int	219	11	Phase I – Unit 219 – Kitchen Island – Ambient (75 liters)	Moderate Trace	1-2	<1	2-3	-	-		
5/8/20	Tape	-	Int	219	10	Unit 219 – Bedroom 2 – Door Trim		-	5-10	-	-	-		
5/8/20	Tape	-	Int	219	**12**	Unit 219 – Bedroom 3 – Painted Drywall		-	30-40	-	-	-		
5/8/20	Tape	-	Int	219	13	Unit 219 – Bedroom 1 – Closet Baseboard		1 S	3-4	-	-	-		
3/11/20	Air	2 min	Int	222	23A	Unit 222 Main living room 2 min.	Moderate	<0.5	-	-	-	8	Insect parts	
3/11/20	Tape	-	Int	222	24T	Unit 222 Exterior wall in living room		-	-	-	-	-		
3/11/20	Air	2 min	Int	223	21A	Corridor outside Unit 223 2 min.	Light	<0.5	-	-	-	-		
3/11/20	Tape	-	Int	223	22T	Corridor outside Unit 223 Exterior wall sheathing		-	-	-	-	<0.5		
3/11/20	Air	2 min	Int	225	19A	Unit 225 Master bedroom 2 min.	Moderate	<0.5	-	-	-	-		
3/11/20	Tape	-	Int	225	17T	Corridor near Unit 225 SMG on sheathing of exterior wall		-	-	-	-	<0.5		
3/11/20	Tape	-	Int	225	18T	Corridor near Unit 225 SMG on sheathing of exterior wall		-	-	-	-	-		
3/11/20	Tape	-	Int	225	20T	Unit 225 Closet off master bedroom on existing gypsum		-	-	-	-	-		
3/11/20	Air	2 min	Int	227	15A	Unit 227 Bedroom off living room 2 min.	Light to Moderate	<1	<0.5	-	-	-		
3/11/20	Bulk	-	Int	227	16B	Unit 227 Backsplash in kitchen		<0.5	-	<0.5	-	-		
3/11/20	Air	2 min	Int	228	9A	Corridor outside Unit 228 2 min.	Light to Moderate	<0.5	-	-	-	-		
3/11/20	Air	2 min	Int	228	11A	Unit 228 Bedroom off living room 2 min.	Light to Moderate	<1	<0.5	-	-	-	Fungal +	
3/11/20	Tape	-	Int	228	10T	Corridor outside Unit 228 Side of wall stud		-	-	-	-	-		
3/11/20	Tape	-	Int	228	12T	Unit 228 Closet off bedroom		-	-	-	-	-		

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
3/11/20	Bulk	-	Int	228	13B	Unit 228 A/C line insulation		-	-	-	-	-		
3/11/20	Tape	-	Int	228	14T	CMU near elevator shaft CMU wall between Unit 228 & 227		-	-	-	-	-		
3/11/20	Air	2 min	Int	231	7A	nit 231 Bedroom off living room 2 min.	Moderate	-	-	-	-	<0.5	Fungal +	
3/11/20	Tape	-	Int	231	8T	Unit 231 Bathroom wall-existing gypsum		-	-	-	-	-		
5/8/20	Air	75 L	Int	232	25	Unit 232 – Living Room – Ambient (75 liters)		5-7	<1	<1	-	-	.	
5/8/20	Tape	-	Int	232	23	Phase II Unit 232 – Painted Dry Wall near sprinkler		-	5-10	-	-	-		
5/8/20	Tape	-	Int	232	24	Unit 232 Inside Plenum		5 S	1-2	5-10	-	-		
3/11/20	Air	2 min	Int	233	5A	Unit 233 Main living room 2 min.	Light	-	-	-	-	-		
3/11/20	Tape	-	Int	233	6T	Unit 233 Closet wall on existing gypsum		-	-	-	-	2-6		
3/11/20	Air	2 min	Int	234	3A	Corridor outside Unit 234 2 min.	Light	<0.5	-	-	-	-		
3/11/20	Tape	-	Int	234	4T	Corridor outside Unit 234 Edge of wall stud		<0.5	-	-	-	-		
3/11/20	Air	2 min	Int	235	1A	Unit 235 Main Living room 2 min.	Light	<0.5	-	-	-	-		
3/11/20	Tape	-	Int	235	2T	Unit 235 Exterior sheathing in bedroom		<0.5	-	-	-	<0.5		
8/27/20	Air	2 min	Int	236	O	Unit 236 Bathroom off bedroom right of main door	Light to Moderate	<1	-	-	-	-	Fungal +	
8/27/20	Air	2 min		236	P	Corridor Fire equipment area by Unit 236	Heavy	20-25	-	-	-	-	Fungal ++ Sample looks like outside air Atypical char particles	Stated to be atypical char; uncertain; no micrograph; discounted
8/27/20	Tape	-		236	N	Corridor Outside Unit 236		-	<0.5	-	-	-	Paint particles	
8/27/20	Tape	-	Int	237	M	Unit 237 Mechanical room wall		<0.5	-	-	-	-	Paint particles	
5/8/20	Air	75 L	Int	238	21	Phase II – Unit 238 – Bathroom Wall Cavity		<1	<0.5	-	-	-		
5/8/20	Tape	-	Int	238	22	Unit 238 – North Wall – Window Sill		4-5	1	-	-	-		
8/27/20	Air	2 min	Int	238	K	Unit 238 Bathroom right of main door	Light to Moderate	<1	<0.5	-	-	-	Fungal +	
8/27/20	Tape	-	Int	238	L	Unit 238 Bathroom right of main door		<0.5	-	-	-	-	Paint particles	
5/8/20	Bulk	-		240	26	Phase II North Hallway Outside Unit 240 – Insulation sample		<0.5	<0.5	-	-	-		
5/8/20	Tape	-		240	27	Phase II – North Hallway outside Unit 240 – Wood ceiling joist		10-20	1-2	-	-	-	Heavy Debris	
8/27/20	Air	2 min	Int	240	G	Unit 240 Bathroom off bedroom left of main door	Light	<1	<0.5	-	-	-		
8/27/20	Air	2 min		240	I	Corridor Outside Unit 240	Light to Moderate	<1	-	-	-	-		
8/27/20	Tape	-	Int	240	H	Unit 240 Wall in bedroom right of main door		-	-	-	-	-	Chaetomium spp. +	
8/27/20	Tape	-		240	J	Corridor Outside Unit 240		<0.5	-	-	-	-		
8/27/20	Air	2 min	Int	242	E	Unit 242 Bathroom off bedroom on right side main door	Light to Moderate	<0.5	-	-	-	-	Fungal +	
8/27/20	Tape	-	Int	242	F	Unit 242 Right bedroom wall stud in bedroom to left of main door		<0.5	-	-	-	-	Fungal +	
8/27/20	Air	2 min		244	A	Corridor By stair enclosure by Unit 244	Light	-	-	-	-	-	Paint particles	
8/27/20	Air	2 min	Int	244	D	Unit 244 Header leading to bathroom on left side main door	Light	-	-	-	-	-		
8/27/20	Tape	-		244	B	Corridor By stair enclosure by Unit 244		-	-	-	-	-	Paint particles	
8/27/20	Tape	-	Int	244	C	Unit 244 Inside main entry door on left stud		<0.5	<0.5	-	-	-		
1/28/20	Air	30 L		301	65A	Hallway outside Unit 301 west corridor intersection	Moderate trace	<1	<1	-	-	<1	Asp/Pen +	
1/28/20	Air	30 L	Int	301	66A	Unit 301 kitchen	Light to Moderate trace	<1	<0.5	-	-	<0.5	Chaetomium spp. +	
1/28/20	Tape	-	Int	301	67T	Unit 301 dry wall main area		-	<0.5	-	-	-		
2/25/20	Air	?	Int	301	1A	Unit 301Main area/ kitchen	Very Light	-	-	-	-	-		
2/25/20	Tape	-	Int	301	2T	Unit 301 Master bathroom existing wall		-	-	-	-	<1		
2/25/20	Bulk	-	Int	301	3B	Unit 301 A/C insulation on lines		-	-	-	-	>50	Spotty paint like particles	
8/11/20	Air	2 min	Int	301	25	Unit 301 Bedroom left	Moderate	-	-	-	-	-	Fungal +	
8/25/20	Air	2 min	Int	301	23A	Unit 301 Windowsill in bedroom to right of main door	Heavy	<0.5	-	-	-	-	Paint particles Fungal +	
8/25/20	Tape	-	Int	301	22T	Unit 301 Windowsill in bedroom to right of main door		<1	<0.5	-	-	-		
8/11/20	Tape	-	Int	302	16	Unit 302 Outside window frame		-	-	-	-	-	Paint particles	
8/11/20	Air	2 min	Int	303	22	Unit 303 On top of HEPA	Moderate	-	-	-	-	-		

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
8/11/20	Tape	-	Int	303	6T	Unit 303 mechanical enclosure		-	-	-	-	-		
8/25/20	Air	2 min	Int	303	25A	Unit 303 Mechanical room	Heavy	-	<0.5	-	-	-	Paint particles	
8/25/20	Tape	-	Int	303	**24T**	Unit 303 Mechanical room		-	20-30	-	-	-	Particles similar to soot	Possible identification error
8/11/20	Tape	-	Int	304	17	Unit 304 Bathroom drywall		-	-	-	-	-	Paint particles	
2/25/20	Air	?	Int	305	4A	Unit 305 Main/ kitchen area	Moderate	-	-	-	-	>50		
2/25/20	Tape	-	Int	305	5T	Unit 305 Back side of gyp wall in bedroom		<0.5	-	-	-	-		
8/11/20	Air	2 min	Int	305	24	Unit 305 bathroom	Moderate	-	-	-	-	-	Paint particles Fungal +	
8/25/20	Air	2 min		305	26A	Corridor Outside Unit 305	Heavy	-	<0.5	-	-	-	Paint particles	
8/25/20	Air	2 min	Int	305	27A	Unit 305 Bedroom bathroom left of main door	Very Heavy	-	-	-	-	-	Paint particles	
8/25/20	Tape	-	Int	305	28T	Unit 305 Bedroom exterior wall right of main door		<1	<1	-	-	-		
8/25/20	Tape	-	Int	305	29T	Unit 305 Bathroom wall to left of main door		-	<0.5	-	-	-		
2/25/20	Air	?	Int	306	6A	Unit 306 Main area/ kitchen	Heavy	-	-	-	-	>50		
2/25/20	Tape	-	Int	306	7T-	nit 306 Bedroom – existing gyp wall		-	-	-	-	10-15	Spotty paint like particles	
8/11/20	Tape	-	Int	306	20	Unit 306 Exterior door right side		-	-	-	-	-	Paint particles Fungal +++	
1/28/20	Air	30 L	Int	307	68A	Unit 307 Bedroom 2	Light trace	<0.5	<0.5	-	-	-	Asp/Pen +	
1/28/20	Tape	-	Int	307	69T	Unit 307 Bedroom 2 N. wall existing		-	30-40	-	-	-	Could be paint but particles are not all spheres	
8/11/20	Tape	-	Int	307	19	Unit 307 Entryway above door		<1	-	-	-	-	Paint particles Fungal +++	
8/25/20	Air	2 min	Int	307	30A	Unit 307 Bathroom to right of main door	Moderate	<0.5	<0.5	-	-	-	Paint particles	
8/25/20	Tape	-	Int	307	31T	Unit 307 kitchen wall		-	-	-	-	-	Paint particles	
8/25/20	Tape	-		307	32T	Corridor Outside Unit 307		-	-	-	-	-		
1/28/20	Tape	-	Int	308	77T	Unit 308 bottom floor of room 408 moisture stain		<1	<1	-	-	-		
8/11/20	Tape	-	Int	308	18	Unit 308 (B) Utility room wall		<0.5	-	-	-	-	Paint particles	
8/11/20	Tape	-	Int	308	21	Unit 308A Utility room stud		<0.5	-	-	-	-	Paint particles	
8/11/20	Tape	-	Int	309	23T	Unit 309 above window left room		-	-	-	-	-	Paint particles	
8/25/20	Air	2 min	Int	309	33A	Unit 309 Bathroom off bedroom right of main door	Moderate	<0.5	<0.5	-	-	-	Paint particles	
2/25/20	Air	?	Int	310	8A	Unit 310 Living room	Light to Moderate	-	-	-	-	15-18		
2/25/20	Tape	-	Int	310	9T-	nit 310 Back gyp wall in master closet		-	-	-	-	<0.5		
2/25/20	Tape	-	Int	310	10T	Unit 310 Ceramic backsplash in kitchen		-	-	-	-	<1		
1/28/20	Air	30 L		312	70A	Outside Unit 312 West corridor	Light trace	<0.5	<0.5	-	-	<0.5	Fungal spores +	
1/28/20	Tape	-		312	71T	stud east side of corridor outside Unit 312		-	-	-	-	<1 N		
1/28/20	Air	30 L	Int	313	72A	Unit 313 kitchen air sample	Very light trace	<0.5	-	-	-	<0.5		
1/28/20	Tape	-	Int	313	72T	Unit 313 tape sample of tile backsplash		<0.5	-	-	-	20-30		
1/28/20	Tape	-	Int	313	73T	Unit 313 Bathroom 2 existing wall		-	-	-	-	15-30		
2/25/20	Air	?	Int	315	11A	Unit 315 Bedroom	Moderate	2	<0.5	-	-	5-6		
2/25/20	Tape	-	Int	315	12T	Unit 315 Furnace room existing dry wall		<0.5	<0.5	-	-	2-4		
3/11/20	Air	2 min	Int	315	38A	Corridor outside Unit 315 Retest. 2 min.	Moderate	-	-	-	-	35-45		
3/11/20	Air	2 min	Int	315	39A	Unit 315 Retest. 2 min.	Light to Moderate	<0.5	-	-	-	40-45		
3/11/20	Tape	-	Int	315	40T	Unit 315 Closet off bathroom. Existing gypsum wall.		-	-	-	-	2-10		
5/8/20	Air	75 L	Int	315	15	Phase I – Unit 315 – Bedroom – Ambient (75 liters)	Light Trace	12-15	2-3	4-6	-	-		
5/8/20	Tape	-	Int	315	16	Unit 315 – Living Room Outlet Cover		1 S	2-3	1	-	-		
5/8/20	Tape	-	Int	315	17	Unit 315 – Bathroom Closet – Door Trim		1 S	2-3	5-8	-	-		
2/25/20	Air	?	Int	316	13A	Unit 316 common area kitchen/living room	Moderate	<1	-	-	-	3-4		
2/25/20	Air	?	Int	316	15A	Main corridor outside Unit 316	Light	-	-	-	-	-		
2/25/20	Tape	-	Int	316	14T	Unit 316 Water- damaged exterior wall in bedroom		-	-	-	-	-		
2/25/20	Tape	-	Int	316	17T	Backside of gyp outside Unit 316		-	-	-	-	-		

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1/28/20	Air	30 L		319	74A	outside Unit 319 south corridor	Very light trace	<0.5	<0.5	-	-	<0.5		
1/28/20	Air	30 L	Int	319	78A	Unit 319 Bedroom 2 SW	Light trace	-	<0.5	-	-	-		
1/28/20	Tape	-		319	75B	Corridor outside Unit 319 bulk AC line		-	<0.5	-	-	-		
1/28/20	Tape	-		319	76T	Gypsum in corridor outside Unit 319		-	<0.5	-	-	-		
1/28/20	Tape	-	Int	319	79T	Unit 319 Bedroom 2 closet		-	-	-	-	5-10		
2/25/20	Bulk	-	Int	320	16B	Insulation A/C line for Unit 320 in corridor		-	-	-	-	-		
2/25/20	Air	?	Int	321	18A	Unit 321 Common area kitchen/living room	Very Light	-	-	-	-	-		
2/25/20	Tape	-	Int	321	19T	Unit 321 Bedroom gyp wall existing		-	-	-	-	2-10		
2/25/20	Tape	-	Int	321	20T	Unit 321 Furnace room existing gyp wall		-	-	-	-	5-20		
2/25/20	Air	?	Int	323	21A	Unit 323 Bedroom	Very Light	-	-	-	-	-		
2/25/20	Tape	-	Int	323	22T	Unit 323 Living room exterior wall sheathing		-	-	-	-	<0.5		
1/28/20	Air	30 L	Int	325	80A	Unit 325 Bedroom 1	Very light trace	<0.5	-	-	-	<0.5		
1/28/20	Tape	-	Int	325	81T	Unit 325 Bedroom 2 back side of ext. sheathing		-	<0.5	-	-	-		
1/28/20	Tape	-	Int	325	82T	Unit 325 Mechanical room wall preexisting		-	-	-	-	10-20		
2/25/20	Air	?		325	23A	Main corridor outside Unit 325	Very Light	-	-	-	-	-		
2/25/20	Tape	-	Int	325	24T	Main corridor staining exterior wall in corridor outside Unit 325		-	-	-	-	<0.5		
2/25/20	Tape	-	Int	325	25T	Main corridor staining exterior wall outside Unit 325		-	<0.5	-	-	<0.5		
2/25/20	Air	?	Int	326	26A	Unit 326 bedroom	Light	<0.5	-	-	-	2		
2/25/20	Tape	-	Int	326	27T	Unit 326 Staining on exterior wall sheathing in bedroom		<0.5	-	-	-	2-4		
2/25/20	Tape	-	Int	326	28T	Unit 326 Ceramic tile backsplash in kitchen		-	-	-	-	<1		
2/25/20	Air	?		328	29A	Main corridor outside Unit 328	Light	-	-	-	-	<1		
2/25/20	Air	?	Int	328	31A	Unit 328 bedroom	Light	-	-	-	-	<1		
2/25/20	Tape	-	Int	328	32T	Unit 328 Bedroom closet existing gap		-	-	-	-	10-15		
2/25/20	Air	?	Int	334	33A	Unit 334 Main living room	Light	<1	-	-	-	2		
2/25/20	Tape	-	Int	334	34T	Unit 334 Bedroom closet – existing gyp		-	-	-	-	>50		
2/25/20	Air	?	Int	335	35A	Main corridor outside Unit 335	Light	-	-	-	-	<1	Some of the char- like particles were atypical	
3/11/20	Air	2 min	Int	335	36A	Corridor outside Unit 335 Retest. 2 min.	Light to Moderate	<0.5	-	-	-	-	Fungal +	
3/11/20	Tape	-	Int	335	37T	Corridor outside Unit 335 Exterior wall stud		-	-	-	-	-		
5/8/20	Air	75 L	Int	336	29	Unit 336 – kitchen Island – Ambient (75 liters)	Very Heavy	45-50	5-8	1-2	-	-		
5/8/20	Tape	-	Int	336	30	Unit 336 – Living Room - window trim		4-6	2-3	3-5	-	-		
5/8/20	Air	75 L		342	28	Phase II – North Hallway 3rd floor near Unit 342 – Ceiling Cavity (75 liters)		10	2-4	1-2	-	-	Fungal spores Asp/Pen ++ Chaetomium spp.	
5/8/20	Air	75 L	Int	344	31	Phase II – Unit 344 – Bedroom 2 – Ambient (75 liters)	Very Heavy	25	10	-	-	-	Numbers are estimated as particle trace was very heavy	
5/8/20	Tape	-	Int	344	32	Unit 344 – Master Bed - Window sill		1-2	5-7	7-12	-	-		
5/8/20	Tape	-	Int	344	33	Unit 344 – Guest Closet - Baseboard		1-2	10-15	25-30	-	-		
1/9/19	Air	30 L	Int	401	20	Unit 401 common area by kitchen	Light trace	<1	<1	<0.5	-	-		
1/28/20	Air	30 L	Int	401	9A	Unit 401 kitchen	Light to Moderate trace	<1	<0.5	-	-	-		
1/28/20	Tape	-	Int	401	10T	Unit 401 Stud S wall backside Master bath (in kitchen)		-	-	-	-	3-5		
1/28/20	Tape	-		401	11T	Outside Unit 401 corridor, Unit #2 Floor 4 fan coil Unit (turbine)		<1	-	-	-	1-3		
1/28/20	Tape	-		401	12T	outside Unit 401 corridor, Unit #2 Floor 4 fan coil Unit exterior,		<1	<1	-	-	-		
1/28/20	Tape	-	Int	401	13T	Top of bottom board floor truss, in ceiling in kitchen Unit 401		-	-	-	-	10-15		
1/28/20	Tape	-	Int	401	14T	Unit 401 Above patio door frame		-	-	-	-	5-10		

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
1/9/19	Air	30 L	Int	403	21	Unit 403 common kitchen area	Light trace	<1	<0.5	1	-	-		
1/28/20	Air	30 L	Int	403	15A	Unit 403 kitchen	Light trace	<0.5	<0.5	-	-	-	Asp/Pen +	
1/28/20	Tape	-	Int	403	16T	Unit 403 North wall existing MBR		-	-	-	-	20-30		
1/9/19	Air	30 L		404	23	Corridor near Unit 404	Very Light trace	-	-	-	-	-		
1/9/19	Air	30 L	Int	404	24	Unit 404 kitchen/common area	Very Light trace	<0.5	<0.5	-	-	-		
1/28/20	Air	30 L	Int	404	21A	Unit 404 2 story Unit kitchen	Light trace	<0.5	<0.5	-	-	-		
1/28/20	Tape	-	Int	404	22T	Unit 404 Living room stud N. wall		-	-	-	-	10-15		
1/28/20	Tape	-	Int	404	23T	Unit 404 upstairs loft West wall existing		-	-	-	-	3-5		
1/28/20	Tape	-		404	24T	Railing cap Unit 404 at landing		-	-	-	-	5-8		
1/9/19	Air	30 L	Int	405	22	Unit 405 common kitchen area	Light trace	<1	<0.5	-	-	-		
1/28/20	Air	30 L	Int	405	17A	Unit 405 kitchen	Light trace	<1	<0.5	-	-	-		
1/28/20	Tape	-	Int	405	18T	Unit 405 South wall dining area		-	-	-	-	2-4		
1/28/20	Tape	-	Int	405	19T	Unit 405 BR floor NE corner		1-2	-	-	-	2-4	Chaetomium spp. +	
1/28/20	Bulk	-	Int	405	20B	Bulk insulation Unit 405 Mech room		-	-	-	-	-		
3/25/20	Bulk	-	Int	406	1	Unit 406 Flooring (gypcrete) from in front of patio door		-	-	-	-	-		
3/25/20	Bulk	-	Int	406	2	Unit 406 Trimmer stud from wall		<1	-	-	-	-		
1/9/19	Air	30 L	Int	407	25	Unit 407 kitchen/common area	Light trace	<0.5	<0.5	1	-	-		
1/28/20	Air	30 L	Int	407	25A	Unit 407 kitchen	Light trace	<1	<0.5	-	-	-		
1/28/20	Air	30 L	Int	407	28A	Unit 407 Bedroom 2	Light trace	<0.5	<0.5	-	-	-	Asp/Pen +.	
1/28/20	Tape	-	Int	407	26T	East wall wet sheathing Bedroom 2 Unit 407		-	-	-	-	-	Trichoderma spp. like ++++	
1/28/20	Tape	-	Int	407	27T	Unit 407 East wall wet stud Bedroom 2		-	-	-	-	-	Trichoderma spp. like ++++	
3/25/20	Bulk	-	Int	407	3	Unit 407 Right bedroom, lower right of window		-	-	-	-	-		
3/25/20	Bulk	-	Int	407	4	Unit 407 Exterior wall stud		-	-	-	-	-		
1/9/19	Air	30 L	Int	408	8	Phase (Bldg.) #1 Unit 408 kitchen/main area	Moderate trace	1	-	-	4-5	-		
1/28/20	Air	30 L	Int	408	29A	Unit 408 kitchen	Light trace	<1	-	-	-	<1	Note floor soft in kitchen - hazard	
1/28/20	Tape	-	Int	408	30T	Unit 408 kitchen cabinet (ext.)		-	-	-	-	-		
1/28/20	Tape	-	Int	408	31T	Unit 408 Interior kitchen cabinet		-	-	-	-	50+		
1/28/20	Tape	-	Int	408	32T	Master bedroom Unit 408 West wall stud Right side of window		-	-	-	-	-		
3/25/20	Bulk	-	Int	408	5	Unit 408 Gypcrete floor in living room		-	-	-	-	-		
1/9/19	Air	30 L	Int	411	9	Phase (Bldg.) #1 Unit 411 kitchen/main area	Moderate trace	<11	-	15-16	-	-	.	Likely error "Char less <11". Possible cooking-related residues
1/28/20	Air	30 L	Int	411	33A	Unit 411 kitchen	Light trace	<0.5	<0.5	-	-	-		
1/28/20	Tape	-	Int	411	34T	Unit 411 kitchen wall tile		-	-	-	-	<0.5		
1/28/20	Tape	-	Int	411	35T	Unit 411 Bathroom wall existing		-	-	-	-	-		
3/25/20	Bulk	-	Int	411	6	Unit 411 Bedroom floor gypcrete		-	-	-	-	-		
3/25/20	Bulk	-	Int	411	7	Unit 411 Balcony zip sheathing		<1	-	-	-	-		
3/25/20	Bulk	-	Int	411	8	Unit 411 Hardi-trim		-	-	-	-	-		
1/9/19	Air	30 L	Int	413	5	Phase (Bldg.) #1 Unit 413 kitchen/main area	Light trace	<0.5	<0.5	2	-	-		
1/28/20	Air	30 L	Int	413	36A	Unit 413 two story kitchen 4 bedrooms	Light trace	<0.5	<0.5	-	-	-		
1/28/20	Tape	-	Int	413	37T	Unit 413 inside kitchen cabinet		-	-	-	-	-		
1/28/20	Tape	-	Int	413	38T	Unit 413 concealed space by front door on wood stud		-	-	-	-	<0.5		
1/28/20	Air	30 L	Int	415	45A	Unit 415 Bedroom south east bedroom	Light trace	<0.5	<0.5	-	-	<1		
1/9/19	Air	30 L	Int	416	6	Phase (Bldg.) #1 Unit 416 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-	The carbon black/soot particles had characteristics of both soot and carbon black- loose sphere clusters of soot- like particles.	Possible cooking-related residues
1/9/19	Air	30 L		416	7	Phase (Bldg.) #1 corridor in Bldg. #1 outside Unit 416	Moderate to Heavy Trace	<1	-	-	50+	-		

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
1/28/20	Air	30 L	Int	416	41A	Unit 416 Utility closet for washer/dryer	Light trace	<1	-	-	-	-		
1/28/20	Air	30 L	Int	416	43A	Unit 416 duct test RA pulling from laundry room	Moderate trace	<0.5	<1	-	-	-		
1/28/20	Tape	-	Int	416	42T	Unit 416 Utility closet occupancy separation wall		-	-	-	-	1-2		
1/28/20	Tape	-	Int	416	44T	Unit 416 kitchen ceramic tile south wall		-	-	-	-	20-30		
7/16/20	Air	2 min		416	8A	parking ramp Storage Unit 416	Moderate	5	<1	-	-	-	Fungal +	
1/28/20	Tape	-		417	40T	Hallway Unit 417 back side of gypsum concealed space		-	-	-	-	<0.5		
5/8/20	Air	75 L	Int	417	18	Unit 417 – Loft – Ambient (75 liters)		10	2	5	-	-		
5/8/20	Tape	-	Int	417	19	Unit 417 – Loft - Baseboard		-	1	1-5	-	-		
5/8/20	Tape	-	Int	417	20	Unit 417 – Bedroom – Window Sill		<0.5	<0.5	-	-	-		
3/25/20	Bulk	-	Int	418	9	Unit 418 Bedroom trimmer stud		-	-	-	-	-		
7/16/20	Tape	-		418	9T-	parking ramp Storage Unit 418		1-2	<1	-	-	-		
7/16/20	Tape	-		420	10T	parking ramp Storage Unit 420		1-2	<1	-	-	-		
1/9/19	Air	30 L	Int	422	10	Unit 422 kitchen/main area	Moderate to Heavy Trace	<1	-	-	50+	-		Possible cooking-related residues
1/28/20	Air	30 L	Int	422	46A	Unit 422 closet	Light trace	<0.5	<0.5	-	-	<1		
1/28/20	Bulk	-	Int	422	47B	Unit 422 Bulk closet sheetrock sample		5-10	5-10	-	-	-		
1/28/20	Tape	-	Int	422	48T	Unit 422 West wall living room existing		-	-	-	-	<0.5		
1/9/19	Air	30 L	Int	423	11	Unit 423 kitchen/main area	Moderate to Heavy Trace	-	-	-	50+	-		Possible cooking-related residues
1/28/20	Air	30 L	Int	423	49A	Unit 423 kitchen	Light trace	<0.5	<0.5	-	-	-	Asp/Pen +	
1/28/20	Tape	-	Int	423	50T	Unit 423 top of refrigerator alcove wood frame		-	-	-	-	2-4		
1/9/19	Air	30 L		424	12	East corridor outside Unit 424	Moderate trace	-	-	-	50+	-		
1/28/20	Air	30 L		425	51A	Corridor outside Unit 425	Light trace	<1	<0.5	-	-	-		
1/28/20	Tape	-		425	52T	Corridor outside Unit 425 on east gypsum		-	-	-	-	2-4		
1/28/20	Tape	-		425	53T	Corridor outside Unit 425 water stain on east dry wall		-	-	-	-	-		
1/9/19	Air	30 L	Int	426	13	Unit 426 kitchen/main area	Moderate trace	<1	-	-	50+	-		Possible cooking-related residues
1/28/20	Air	30 L	Int	426	55A	Unit 426 main area	Light trace	<1	<0.5	-	-	<0.5		
1/28/20	Tape	-		426	54T	outside Unit 426 Corridor on fire extinguisher cabinet		-	<0.5	-	-	-		
1/28/20	Tape	-	Int	426	56T	Unit 426 gypsum existing wall		-	<1	-	-	-		
1/28/20	Tape	-	Int	426	57T	Unit 426 N. wall of the bathroom frame		-	-	-	-	5-10		
3/25/20	Bulk	-	Int	427	11	Unit 427 Bedroom window sheathing		1-15	-	-	-	-	Spotty for both fungal growth and char particles	
1/9/19	Air	30 L	Int	428	14	Unit 428 kitchen/main area	Moderate trace	<1	-	-	14-16	-		Possible cooking-related residues
1/28/20	Air	30 L	Int	428	58A	Unit 428 kitchen	Light trace	<0.5	-	-	-	<0.5	Chaetomium spp. +	
1/28/20	Tape	-	Int	428	59T	Unit 428 kitchen tile		-	<1	-	-	-		
3/25/20	Bulk	-	Int	428	10	Unit 428 Balcony zip sheathing		<0.5	-	-	-	-	The sample was very wet.	
1/28/20	Air	30 L	Int	429	60A	Unit 429 kitchen	Light trace	<1	<0.5	-	-	<0.5		
1/28/20	Tape	-	Int	429	61T	Unit 429 Backside of ext. bedroom wall		-	<0.5	-	-	-		
1/28/20	Tape	-	Int	429	62T	Unit 429 kitchen alcove base east wall		-	-	-	-	1-2		
1/9/19	Air	30 L	Int	430	15	Unit 430 kitchen/main area	Moderate trace	6-7	1-2	3-4	-	-		Possible cooking-related residues
1/9/19	Air	30 L		430	16	Corridor outside Unit 430	Moderate trace	8-9	-	<1	-	-		
1/28/20	Air	30 L		430	63A	Corridor outside Unit 430	Light trace	<1	<1	-	-	<1		
1/28/20	Air	30 L	Int	430	64A	Unit 430	Light trace	<0.5	<0.5	-	-	-		
1/28/20	Bulk	-	Int	430	64B	Unit 430 bulk sample		-	-	-	-	10-15		
1/9/19	Air	30 L	Int	433	19	Unit 433 main/ kitchen area	Light trace	<1	<1	-	-	-		
1/28/20	Air	30 L	Int	433	7A	Unit 433 kitchen	Moderate trace	<1	<0.5	-	-	-		
1/28/20	Tape	-	Int	433	8T	Unit 433 pass through vent		-	<1	-	-	-		

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
1/9/19	Air	30 L		434	18	Corridor outside Unit 434	Light trace	4-5	<0.5	<1	-	-		
1/28/20	Tape	-	Int	434	6T	Corridor 435 West wall blocking between Unit 434		-	-	-	-	2-3		
1/9/19	Air	30 L	Int	435	17	Unit 435 kitchen/main area	Moderate trace	6-7	1-2	<1	-	-		
1/28/20	Tape	-	Int	435	2T	Unit 435 N. wall Bathroom 2 wood		-	-	-	-	5-10		
1/28/20	Tape	-	Int	435	3T	Unit 435 Master Bedroom, backside of exterior OSB. SW corner		-	-	-	-	<1 N		
1/28/20	Tape	-		435	4T	Unit 435 SW corner Floor sheathing by gyp.		-	-	-	-	20-30		
8/11/20	Air	2 min	Int	436	10A	Unit 436 Common area	Heavy	<1	-	-	-	-	Sheetrock particles	
8/25/20	Air	2 min	Int	436	17A	nit 436 Bdrm.	Moderate	-	<0.5	-	-	-	Paint particles	
8/25/20	Tape	-	Int	436	18T	Unit 436 Mechanical room		<0.5	-	-	-	-		
8/25/20	Tape	-	Int	436	19T	Corridor Outside Unit 436		<0.5	<0.5	-	-	-	Paint particles	
5/8/20	Tape	-		437	50	Phase II – Roof – A/C cover of Unit 437 or 337		1 S	5-10	-	-	-	Fungal ++++ Spotty soot	
7/16/20	Air	2 min	Int	437	27A	Unit 437 Common area	Moderate	7-8	<0.5	-	-	-		
7/16/20	Tape	-	Int	437	28T	Unit 437 Common area close to utility closet stud		5-15	-	-	-	-	Fungal +	
8/11/20	Air	2 min	Int	437	9A	Unit 437 Bathroom on the left	Heavy	<1	<0.5	-	-	-	Sheetrock particles	
8/11/20	Air	2 min		437	11A	outside Unit 437 corridor	Heavy	<1	<0.5	-	-	-	Sheetrock particles	
5/8/20	Air	30 L	Int	438	34	Phase II – Unit 438 – Living Room Circuit Box		3	15-20	-	-	-		
5/8/20	Tape	-	Int	438	35	Unit 438 – Living Room – Painted Dry wall		<1	10-12	1-2	-	-		
8/11/20	Air	2 min	Int	438	8A	Unit 438 Common area	Heavy	<0.5	-	-	-	-	Sheetrock particles	
8/11/20	Tape	-	Int	438	12	Unit 438 Upper soffit in roof assembly on stud		-	-	-	-	-		
8/25/20	Air	2 min	Int	438	16A	Unit 438 Main bathroom off kitchen	Light to Moderate	<0.5	-	-	-	-		
7/16/20	Tape	-	Int	439	25T	Unit 439 Bathroom south wall double top plate		<0.5	-	-	-	-	Fungal +++/++++	
7/16/20	Tape	-	Int	439	26T	Unit 439 North bedroom SW corner OSB water damage stain		-	-	-	-	-	Fungal growth ++++ Bispora spp. Pres.	
8/11/20	Air	2 min	Int	439	7A	Unit 439 Mechanical enclosures	Moderate	<0.5	-	-	-	-	Fungal +	
8/25/20	Air	2 min		439	14A	Corridor outside Unit 439	Moderate	<0.5	-	-	-	-	Paint particles	
8/25/20	Tape	-		439	15T	Corridor Outside Unit 439		-	-	-	-	-	Paint particles	
7/16/20	Air	2 min	Int	440	20A	Unit 440 North bedroom	Light to Moderate	1-2	-	-	-	-		
7/16/20	Air	2 min		440	23A	Corridor outside Unit 440	Moderate	4-5	<0.5	-	-	-	Fungal +	
7/16/20	Tape	-	Int	440	21T	Unit 440 Utility closet cupboard s. wall back side		-	-	-	-	-	Chaetomium spp. ++++ Other fungal ++++	
7/16/20	Tape	-	Int	440	22T	Unit 440 Utility closet N. wall gypsum wall		-	-	-	-	-	Chaetomium spp. ++++	
7/16/20	Tape	-		440	24T	Corridor outside Unit 440 east wall nailer block sub floor		<1	-	-	-	-	Fungal +++/++++	
8/11/20	Air	2 min	Int	440	6A	Unit 440 Mechanical enclosures	Moderate	<0.5	-	-	-	-	Sheetrock dust	
8/25/20	Air	2 min	Int	440	10A	nit 440 Bathroom ceiling to left of main door	Light to Moderate	<0.5	-	-	-	-	Sheetrock dust	
8/25/20	Tape	-		440	11T	Corridor Outside Unit 440		<0.5	<0.5	-	-	-	Paint particles	
8/25/20	Tape	-	Int	440	12T	Unit 440 kitchen backsplash		<0.5	<0.5	-	-	-	Paint particles Fungal +	
8/25/20	Tape	-	Int	440	13T	Unit 440 Mechanical room wall stud		-	-	-	-	-	Paint particles	
7/16/20	Air	2 min	Int	441	18A	Unit 441 South bedroom	Light to Moderate	1-2	<0.5	-	-	-	Fungal +	
7/16/20	Tape	-	Int	441	17T	Unit 441 South bedroom south wall stud		-	-	-	-	-	Fungal +++/++++	
7/16/20	Tape	-	Int	441	**19T**	Unit 441 Bathroom north stud in nook		40 -50	-	-	-	-		
8/11/20	Air	2 min	Int	441	5A	it 441 Rt side of bathroom by bedroom	Moderate	<0.5	-	-	-	-		
5/8/20	Tape	-	Int	442	36	Unit 442 – Living Room – Doorbell Casing		1-2	1-2	1-2	-	-		
5/8/20	Tape	-	Int	442	37	Unit 442 – Master Bath – Mirror Trim		1-2	3-4	4-5	-	-		
7/16/20	Air	2 min		442	12A	Corridor outside room Unit 442 HVAC cavity	Moderate	1-2	-	-	-	-	Fungal +	
7/16/20	Air	2 min	Int	442	14A	Unit 442 north bedroom	Light	1	<0.5	-	-	-	Fungal +	
7/16/20	Tape	-	Int	442	10T	Unit 442 Utility closet sheetrock lower		-	-	-	-	-	Chaetomium spp. ++++ Other fungal ++++ Insect/ arthropod fecal pellets	

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
7/16/20	Tape	-	**Int**	442	11T	Unit 442 Walk-in closet west stud		-	-	-	-	-	Fungal +++/++++	
7/16/20	Bulk	-	**Int**	442	13B	Corridor outside Unit 442 East wall sheathing facing the parking ramp		-	-	-	-	-	Mushroom growth ++++	
7/16/20	Tape	-		442	**15T**	Corridor outside Unit 442 OSB sheathing facing parking ramp		20-50	-	-	-	-		
7/16/20	Tape	-	**Int**	442	16T	Unit 442 North bedroom south wall stud		3-5	<0.5	-	-	-		
8/11/20	Air	2 min	**Int**	442	3A	nit 442 bathroom off bedroom	Moderate	<1	-	-	-	-	Fungal +	
8/11/20	Air	2 min	**Int**	442	4A	utside Unit 442 corridor	Heavy	<0.5	-	-	-	-	Sheetrock dust	
8/11/20	Tape	-	**Int**	442	13	Unit 442 Upper soffit in roof on OSB		-	-	-	-	-		
8/11/20	Tape	-	**Int**	442	14	Unit 442 Upper soffit on backside of truss strut		-	-	-	-	-		
8/25/20	Air	2 min	**Int**	442	6A	it 442 Upper ceiling area in bathroom left of main door.	Light	<0.5	<0.5	-	-	-	Fungal +	
8/25/20	Tape	-	**Int**	442	7T	Corridor Outside Unit 442		<0.5	-	-	-	-	Paint particles	
8/25/20	Tape	-	**Int**	442	8T	Unit 442 Closet wall in bedroom to right of main door		-	-	-	-	-		
8/25/20	Tape	-	**Int**	442	9T	Unit 442 Closet wall in bedroom to left of main door		<0.5	-	-	-	-	Paint particles	
7/16/20	Air	2 min	**Int**	443	9A	Unit 443 South bedroom west end	Light to Moderate	1	-	-	-	-	Fungal +	
7/16/20	Tape	-	**Int**	443	7T	Unit 443 East bathroom tub interior wall backer wood divertor		-	-	-	-	-	Fungal +++/++++	
7/16/20	Tape	-	**Int**	443	8T	Unit 443 kitchen nailer board		-	-	-	-	-	Fungal +++/++++	
8/11/20	Air	2 min	**Int**	443	2A	nit 443 common area	Moderate to heavy	<1	<0.5	-	-	-	Fungal + Sheetrock dust	
7/16/20	Air	2 min	**Int**	444	4A	Unit 444 North bedroom	Light to Moderate	<1	-	-	-	-		
7/16/20	Tape	-	**Int**	444	5T	Unit 444 North bedroom west side of exterior stud		<0.5	-	-	-	-	Fungal +	
7/16/20	Tape	-	**Int**	444	6T	Unit 444 South bedroom east wall interior stud lower		-	-	-	-	-	Fungal +++/++++	
8/11/20	Air	2 min	**Int**	444	1A	Unit 444 Closet off bedroom	Moderate	<1	-	-	-	-	Sheetrock dust	
8/25/20	Air	2 min		444	1A	rridor outside Unit 444 By exit enclosure	Light to Moderate	<0.5	-	-	-	-	Fungal +	
8/25/20	Air	2 min	**Int**	444	3A	it 444 Plenum of hallway to right of main area	Light to Moderate	<0.5	<0.5	-	-	-		
8/25/20	Tape	-	**Int**	444	4T	it 444 Closet stud in wall off master bedroom		<0.5	<0.5	-	-	-		
8/25/20	Tape	-	**Int**	444	5T	Unit 444 Closet stud in wall of bedroom		-	<0.5	-	-	-		
5/8/20	Air	75 L	**Int**	445	53	Phase III – Unit 445 (75 liters)		5-7	<1	<1	-	-	Asp/Pen ++	Unknown location
5/8/20	Tape	-		445	60	Phase III – In-ceiling A/C Duct (top) outside Unit 445		8-12	1-2	2-5	-	-	Fungal +++	
5/8/20	Tape	-	**Int**	446	54	Phase III – Unit 446 – Bedroom window sill		4-8	1-2	1-3	-	-	Fungal +	
5/8/20	Tape	-		447	51	Phase III – E-W Hallway – A/C unit by Unit 447		3-8	2-5	-	-	-	Fungal ++++	
5/8/20	Tape	-	**Int**	447	52	Phase III – Unit 447 – Master Bedroom Door header		7-15	2-5	3-5	-	-	Fungal +++	
5/8/20	Tape	-	**Int**	448	55	Phase III – Unit 448 – Hallway Stud wall		2-5	1	3-8	-	-	Fungal +++	
5/8/20	Air	75 L	**Int**	449	56	Phase III – Unit 449 – By kitchen Island (75 liters)		1	<0.5	<0.5	-	-	Asp/Pen ++	
5/8/20	Tape	-	**Int**	450	57	Phase III – Unit 450 – Master bedroom Light switch box		4-10	1	2-5	-	-	Fungal +++	
5/8/20	Tape	-	**Int**	451	58	Phase III Unit 451 – Master Bath stud wall		5-10	2-3	-	-	-	Asp/pen like ++	
5/8/20	Tape	-	**Int**	452	**59**	Phase III Unit 452 – Living Room Window frame		2-4	1	10-20	-	-	Fungal +	
5/8/20	Tape	-	**Int**	453	62	Phase IV Unit 453 – Framing above fridge		-	-	-	-	-	Aspergillus ++++ Other fungal Insect parts	
5/8/20	Tape	-	**Int**	454	69	Phase IV – Unit 454 – Subfloor dryer duct in Master Bedroom		2-5	<1	-	-	-	Asp/Pen ++++ Sordaria spp. ++	
5/8/20	Tape	-	**Int**	455	68	Phase IV Unit 455 – Above doorway into guest bedroom		2-5	<1	-	-	-	Asp/Pen ++++ Trichoderma spp. ++++	
5/8/20	Tape	-		455	70	Phase IV – Attic Space Elec. Wire between Unit 455 & 456		1 S	<1	-	-	-	Asp/Pen ++++ Other fungal ++++	
5/8/20	Air	75 L		456	64	Phase IV – Hallway between Unit 456 & 457		<1	<0.5	-	-	-	Asp/Pen ++	

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
5/8/20	Tape	-	**Int**	456	67	Phase IV – Unit 456 – Bathroom Door Frame		15	1-2	-	-	-	Asp/Pen ++++ Alternaria spp. +	
5/8/20	Tape	-	**Int**	457	66	Phase IV – Unit 457 – sub floor truss in Living room		8-15	1-3	-	-	-	Asp/Pen ++++ Other fungal ++++	
7/16/20	Air	2 min		466	7A	parking ramp 4th floor inside storage Unit 466	Moderate	5	<0.5	-	-	-	Fungal +	
1/9/19	Air	30 L			1	Phase (Bldg.) #1 outside main entrance on steps	Light trace	<1	<0.5	-	-	-		
1/9/19	Air	30 L			3	Phase (Bldg.) #1 kitchen area behind offices	Light trace	<1	<0.5	-	-	-		
1/9/19	Air	30 L			4	Phase (Bldg.) #1 conference room main level	Light trace	<0.5	<0.5	-	-	-		
1/28/20	Air	30 L			1A	435 kitchen	Heavy trace	3-4	<1	-	-	-	Chaetomium spp. +	
1/28/20	Air	30 L			5A	Corridor outside of 435 between 434	Moderate trace	<1	<0.5	-	-	-		
1/28/20	Air	30 L			39A	- Hallway outside Room 417 south corridor	Light to Moderate trace	<0.5	<0.5	-	-	4-5		
2/25/20	Tape	-			30T	Main corridor wall stud along exterior wall		-	-	-	-	-		Probably around Unit 326
3/19/20	Air	5 min			21A	West hallway (North-South)	Light to moderate	-	-	-	-	<0.5	Fungal +	Unknown location
3/19/20	Air	5 min			23A	North hallway (East-West)	Light	-	-	-	-	<0.5		Unknown location
3/19/20	Air	5 min			25A	East hallway (North-South)	Light	<0.5	-	-	-	<0.5		Unknown location
3/19/20	Air	5 min			27A	South hallway Outlet box	Light	-	-	-	-	-		Unknown location
3/19/20	Tape	-			22T	West hallway Key card outlet box		-	-	-	-	-		Unknown location
3/19/20	Tape	-			24T	North hallway wood framing		-	-	-	-	-		Unknown location
3/19/20	Tape	-			26T	East hallway exterior wall stud		-	-	-	-	-		Unknown location
3/19/20	Tape	-			28T	South hallway outlet box		-	-	-	-	-		Unknown location
3/24/20	Bulk	-			1	South wall phase 5 facing phase 6.		-	-	-	-	-	Basidiospores ++++	
3/24/20	Bulk	-			2	Cut #2 Phase 5 – East Wall		-	-	-	-	-	Fungal growth +++ Cladosporium spp. +++ Asp/Pen like +++	
4/7/20	Bulk	-			1	North Elevation NW corner of building zip sheathing		-	-	-	-	-	Wet sample	
4/7/20	Bulk	-			2	North Elevation NW corner of building zip sheathing		-	-	-	-	-	Wet sample	
4/7/20	Bulk	-			3	North Elevation NW corner of building zip sheathing		-	-	-	-	-	Wet Sample	
4/7/20	Bulk	-			4	Center Courtyard SW corner Tap Paper		-	-	-	-	-	Tease tape samples were taken from multiple locations on the sample	Sample type unclear
4/7/20	Bulk	-			5	Center Courtyard SW corner zip sheathing		2-4	-	-	-	-	Wet Sample	
4/7/20	Tape	-			6	North Elevation NW corner of building organic growth (at location of bulk sample #2 – Tease tape take from this sample	Char [<0.5 – 4] Fungal growth ++++	-	-	-	-	-		Sample type unclear
5/8/20	Air	30 L			43	Phase I – E. Exterior Wall – Behind siding		<1	<0.5	-	-	-	Stachybotrys spp. light.	Unknown location
5/8/20	Air	30 L			44	Phase I E. Exterior Wall – Medium Vent Duct		<0.5	-	-	-	-		Unknown location
5/8/20	Air	75 L			45	Phase I – E. Exterior Wall – Large Vent Duct (75 liters)		<0.5	-	-	-	-		Unknown location
5/8/20	Air	30 L			**48**	Phase IV – S. Exterior Wall – Exhaust Vent Duct		10-15	-	-	-	-	Pine Pollen	Unknown location
5/8/20	Air	75 L			49	Phase I – Roof – Inside A/C Unit housing of 118 or 218 (75 liters)		6	<0.5	-	-	-	Fungal ++++	
5/8/20	Air	75 L			61	Phase IV – Where the hallway turns by stairs		1-2	<0.5	-	-	-	Asp/Pen ++ Alternaria spp.	Unknown location
5/8/20	Tape	-			8	2nd Floor Hall – North Painted Drywall		-	3-10	-	-	-		Unknown location
5/8/20	Tape	-			**14**	Phase I – Floor 2 Mechanical Room – Painted Drywall		-	30-40	-	-	-		Unknown location
5/8/20	Tape	-			41	Phase IV – S. Exterior wall – Behind siding		1 S	2-3	-	-	-		Unknown location

Date	Type	Vol	Interior of Unit	Unit	Carlson ID	Description	Trace density	Char	Soot	Carbon Black	Carbon black/soot	Paint	Carlson Notes	SB Notes
5/8/20	Tape	-			42	Phase I – E. Exterior wall – behind siding		-	15-20	-	-	-	.	Unknown location
5/8/20	Tape	-			**46**	Phase I – E. Exterior wall – Large vent duct (same as #45)		20-25	1-3	1-3	-	-	Heavy pollen and pine pollen	Unknown location
5/8/20	Tape	-			47	Phase I – E. Exterior wall – Exhaust vent duct		3-8	1-3	10-20	-	-	Fungal ++ Heavy pollen and pine pollen	Unknown location
5/8/20	Tape	-			**63**	Phase IV – Mechanical Closet outlet box		5-10	2	-	-	-	Aspergillus ++++	Unknown location
5/8/20	Tape	-			**65**	Phase IV – Top of A/C Unit in N-S Hallway		1-3	15-20	-	-	-	Asp/Pen ++++ Stachybotrys + Other fungal growth	Micrograph says: very spotty on this sample; Unknown location
7/16/20	Air	2 min			1A	parking ramp Under tarps storing for 5th floor cabinets	Moderate to heavy	8-10	<1	-	-	-	Cladosporium spp. ++ Epicoccum spp. + Other fungal + Pollen +	
7/16/20	Air	2 min			4A	parking ramp 4th floor storage container #404	Moderate to heavy	8	<0.5	-	-	-	Fungal +	
7/16/20	Air	2 min			11A	parking ramp 401-433 appliance storage	Heavy	40-50	<1	-	-	-	Fungal + Char and other char-like particles	
7/16/20	Air	2 min			14A	parking ramp #303 third floor	Heavy	40-50	1-2	-	-	-	Fungal +	
7/16/20	Air	2 min			16A	parking ramp unit 321	Moderate	7	<0.5	-	-	-	Fungal +	
7/16/20	Air	2 min			1A	parking Outdoor air sample	Heavy	10-15	<1	-	-	-	Other fungal +	
7/16/20	Tape	-			2T	parking ramp #119 pile on 5th floor		20-25	1-2	-	-	-	Pollen ++	Unknown location
7/16/20	Tape	-			3T	parking ramp 6th floor cabinet door		1-2	<0.5	-	-	-		Unknown location
7/16/20	Tape	-			5T-	parking ramp 4th floor inside surface 466		2-3	<1	-	-	-		
7/16/20	Tape	-			6T-	parking ramp 4th floor inside storage Unit #404		1-2	<1	-	-	-		
7/16/20	Tape	-			12T	parking ramp 321		4-5	<1	-	-	-		
7/16/20	Tape	-			13T	parking ramp Open air garage sinks		15-20	1-2	-	-	-		
7/16/20	Tape	-			15T	parking ramp #303 third floor		4-6	<1	-	-	-		
8/11/20	Tape	-			15	3rd floor Lift level Unit 3 Hall		-	-	-	-	-	Fungal ++++	Unknown location
8/25/20	Air	2 min			20A	Corridor Outside stair enclosure	Moderate	-	<1	-	-	-	Paint particles Fungal +	
8/25/20	Tape	-			2T	Corridor by exit enclosure		-	<0.5	-	-	-	Paint particles	Unknown location
8/25/20	Tape	-			21T	Corridor Outside stair enclosure		<0.5	-	-	-	-		
9/11/20	Tape	-			1T	Stairs A 4th floor stairs exterior wall stud		-	-	-	-	-	Paint particles	
9/11/20	Air	xx min			1A	Outside air by entrance to parking structure	Light to Moderate	<0.5	-	-	-	-	Fungal +	Decription added by SAB + no volume
4/8/20	Air	2 min		Elev	1A	Elevator #1 Floor 1 2 min.	Light to Moderate <50	<1	-	-	-	-		
4/8/20	Air	2 min		Elev	2A	Elevator #2 Floor 1 2 min.	Light <50	<0.5	-	-	-	<1		
4/8/20	Air	2 min		Elev	3A	Elevator #2 Floor 4 2 min.	Light <50	-	-	-	-	1-2		
4/8/20	Air	2 min		Elev	4A	Elevator #1 Floor 4 2 min.	Moderate 792	5-10	-	-	-	-	*The char shape was irregular and could be a false positive. Fungal +++	
5/8/20	Air	75 L		Elev	71	Phase I Cavity below ground floor – Interior elevator (75 liters)		2-3	<0.5	-	-	-	Asp/Pen +	Unknown location
5/8/20	Air	75 L		Elev	72	Phase I Cavity below ground floor – Garage elevator (75 liters)		8-9	2-3	-	-	-		Unknown location
1/9/19	Air	30 L		Lobby	2	Phase (Bldg.) #1 main lobby & reception area	Light to moderate trace	<1	<1	-	-	-		
5/8/20	Tape	-		Lobby	2	Phase I – lobby – South window frame		<0.5	-	-	-	-		
5/8/20	Air	75 L		Lobby	1	Phase I – Lobby - Ambient (75 liters)	Light trace	4-5	<0.5	<0.5	-	-		

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Curriculum Vitae

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EDUCATION

1986	Ph.D., Water Resources and Environmental Engineering, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.
1981	M.S., Technology and Policy Program, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.
1979	B.S., Water and Air Pollution Program, Department of Environmental Science, Rutgers University, New Brunswick, New Jersey.

RESEARCH AND PROFESSIONAL EXPERIENCE

2018-	Director, Environmental Toxicology and Epidemiology Program, The University of Michigan NIEHS T32 Training Center, v, Ann Arbor, MI.
2018-	Professor, Global Public Health, School of Public Health, University of Michigan, Ann Arbor, MI.
2014-5	Visiting Professor, Department of Energy, Politecnico di Torino, Torino, Italy. (sabbatical).
2013-4	Visiting Scholar, The International Council on Clean Transportation, Washington, DC. (sabbatical).
...2011-	Leader, Exposure Assessment Core, The University of Michigan NIEHS P30 Core Center: Lifestage Exposures and Adult Disease.
2010-	Director, Center for Occupational Health and Safety Engineering, A NIOSH T-42 Center, University of Michigan, Ann Arbor, MI.
2007-10	Director, Pilot Project Research Program, NIOSH Education and Research Center, University of Michigan, Ann Arbor, MI.
2006-	Professor of Mechanical Engineering. Faculty of Science and Technology, Universidade de Coimbra, Coimbra, Portugal (sabbatical 2006-7).
2006-	Professor of Civil and Environmental Engineering. College of Engineering, University of Michigan, Ann Arbor, MI.
2002-	Professor of Environmental Health Sciences. School of Public Health, University of Michigan, Ann Arbor, MI.
2002	Acting Head, Environmental Health Program. School of Public Health, University of Michigan, Ann Arbor, MI.
2000-2005	Associate Chair. Department of Environmental Health Sciences, School of Public Health, University of Michigan, Ann Arbor, MI.
1996-7	Visiting Professor. Technical Research Center of Finland, Espoo, Finland; Technical University of Helsinki (Mechanical Engineering), Espoo, Finland; and University of Kuopio (Environmental Sciences), Kuopio, Finland (sabbatical).
1995-2002	Associate Professor of Environmental Health Sciences with Tenure. Department of Environmental and Industrial Health, School of Public Health, University of Michigan, Ann Arbor, MI.
1989-1995	Assistant Professor of Environmental and Industrial Health. Department of Environmental and Industrial Health, School of Public Health, University of Michigan, Ann Arbor, MI.
1993-present	Director, Hazardous Substances Academic Training Program. NIOSH Education and Research Center (formerly Educational Resource Center), University of Michigan, Ann Arbor, MI.
1989-92	Adjunct Assistant Professor of Environmental and Water Resources Engineering. Department of Civil Engineering, Texas A&M University, College Station, TX.

1987, 1988, 1990	Visiting Scientist. International Institute for Applied Systems Analysis, Laxenburg, Austria. (summers, August in 1990)
1986-9	Assistant Professor. Environmental and Water Resources Engineering Division, Department of Civil Engineering, Texas A&M University, College Station, TX.
1986 (May-Aug.)	Research Scholar. International Institute for Applied Systems Analysis, Laxenburg, Austria.
1981-5	Graduate Research Assistant. Energy Laboratory, Massachusetts Institute of Technology, Cambridge, MA.
1981-2	Intern. Massachusetts Port Authority, Boston, MA.
1980	Graduate Research Assistant. Center for Policy Alternatives, Massachusetts Institute of Technology, Cambridge, MA.
1980	Teaching Assistant. Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA.

DISTINCTIONS

1975-9	Dean's List and High Honors, Rutgers University, New Brunswick, NJ.
1981	Technology and Policy Fellowship, Massachusetts Institute of Technology.
1992-4	Chairman, U.S. Working Group on FTIR Spectroscopy, Measurement of Pollution, International Organization of Legal Metrology.
1995-7	Listed in Who's Who in American Education, published by A.N. Marquis.
1997	Outstanding Contribution to Justice and Environmental Safety Award, Flint Genesee United for Action.
2000	Excellence in Community Service Award, Ecology Center, Ann Arbor, MI.
2002-5	Associate Editor, ASCE *Journal of Environmental Engineering*
2003	International Coordinator, 13th Annual Conference, International Society of Exposure Analysis, Stresa, Italy, Sept. 2003
2004	Chair, Resolutions Committee, 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa, Feb. 23-27, 2003.
2006	Professor, Faculty of Science and Technology, Universidade de Coimbra
2007	Delegate, Universities Council on Water Resources
2008	Faculty Associate, Program in the Environment, University of Michigan
2008	Editor, *Journal of Environment and Public Health*
2009-12	Honorary Professor, Department of Occupational and Environmental Health, Medical School, University of KwaZulu-Natal, Durban, South Africa
2011	Faculty Associate, Center for Global Health, University of Michigan.
2011	Fulbright Award for Portugal, J. William Fulbright Foreign Scholarship Board.
2016-18	Honorary Professor, Department of Occupational and Environmental Health, School of Nursing & Public Health, University of KwaZulu-Natal, Durban, South Africa
2017 -	Fellow, Interprofessional Leadership Fellows Program, Center for Research on Learning and Teaching (CRLT), University of Michigan.

STATEMENT OF EXPERIENCE

I have been engaged with occupational and environmental research, teaching and service for over 35 years at several of the leading academic and research institutions. I have authored or co-authored over 200 peer-reviewed journal articles, and 300 conference proceedings, book chapters, and technical reports. I have obtained over 80 external research and training grants. I have served or currently serve as peer-reviewer for many scientific journals, governmental agencies, and other organizations. I have taught and continue to teach occupational and environmental health subjects in graduate courses at the premier educational institutions in Michigan, Texas, Finland, Portugal, Ghana and South Africa, and have been the primary supervisor for over 20 Ph.D. and 60 Masters students. I have served and continue to serve as technical advisor, committee member or chair for various organizations dealing with these topics at local, county, regional, national at international levels, and I have provided outreach and expert testimony in the US and elsewhere. I serve as Center Director

of the NIOSH-supported T42 *Michigan Center for Occupational Health and Safety Engineering*, I lead the *Exposure Assessment Core* of the NIEHS-supported P30 *Michigan Center for Lifestage Environmental Exposure and Disease*, and I direct the NIEHS-supported T32 *Environmental Toxicology and Epidemiology Program*. I support a number of community-based participatory research projects in Detroit, Michigan, and serve as a lead investigator in the Community Allies Against Asthma (CAAA) initiative (a part of the University of Michigan Urban Research Center), and the Community Action to Promote Healthy Environments (with co-PI Amy Schulz).

RESEARCH SUMMARY

My current research addresses a wide range of topics in occupational, indoor and environmental settings that include: *exposure assessment*; *emerging contaminants in occupational and environmental settings*; *biological monitoring; air quality monitoring; indoor air quality* (e.g., assessment and management); *air pollution control engineering* (e.g., vapor and particle air filtration)*; environmental and human health risk assessment*, and *environmental epidemiology*. Other research experience and interests include: *characterization of VOCs in air, soils and fuels, environmental impact assessment, health impact assessment, risk assessment, environmental statistics, uncertainty analysis; VOC measurement techniques* (including Fourier transform infrared spectroscopy, adsorbent collection/thermal desorption); *disinfection by-products in drinking water; hazardous waste/medical waste management; environmental justice; sustainable systems; urban scale air pollutant modeling; environmental impacts of energy production; life cycle analysis*. This research has been supported by government, industry and nonprofit organizations including the US National Institutes of Health (NIEHS, NIOSH, CDC, etc.), the National Science Foundation, the US Environmental Protection Agency, the American Society of Heating, Refrigeration and Air Condition Engineers (ASHRAE), and the World Health Organization, among others. Further details are provided under research support.

The range and scope of research activities are reflected in publications which have appeared in the following journals, (as well as in books, proceedings and reports): *American Journal of Public Health*, *Analytical Chemistry*, *Applied Occupational and Environmental Hygiene*, *Archives of Environmental Health*, *Atmospheric Environment*, *Environmental Research*, *Environmental Science and Technology*, *Environmental Health Perspectives*, *Human and Ecological Risk Assessment*, *Indoor Air*, *International Archives of Occupational and Environmental Hygiene*, *International Journal of HVAC&R Research*, *Journal of Applied Spectroscopy*, *Journal of Environmental Engineering*, *Journal of Environmental Management*, *Journal of Environmental Monitoring*, *Journal of Environmental Toxicology and Chemistry*, *Journal of Exposure Assessment and Environmental Epidemiology*, *Journal of Life Cycle Assessment*, *Journal of the Air and Waste Management Association*, *Journal of the American Industrial Hygiene Association*, *Systems Analysis Modeling and Simulation*, *The Science of the Total Environment*, *and Water Research*, *among others.*

PUBLICATIONS

Peer-Reviewed Journal Articles

Complete List of Published Work in MyBibliography:

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* For these papers, Dr. Batterman was the senior author, and a graduate student or post-doctoral research fellow is listed as first author. + denotes relevant to local situation in Detroit.

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The paper was selected as the Editor's Choice for this issue.

A draft version of the manuscript won the *Harburg Student Award for Excellence in Social Epidemiology*, which includes a cash prize, from the Center for Social Epidemiology and Population Health, April 22, 2019.

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Submitted Manuscripts

1. Stuart Batterman, Toby Lewis, Thomas Robins, Graciela Mentz, Chad Milando, Bhramar Mukherjee, Community Allies Against Asthma Steering Committee, "Effects of SO_2 exposures below the National Ambient Standard in Children with Asthma in Detroit, Michigan" In review.
2. Parker, E., **S. Batterman**, T. Lewis, B. Israel, T. Robins. "Adult behaviors determine the effectiveness of an air filter intervention for children with asthma.",
3. Xin Wang, Bhramar Mukherjee, Carrie A. Karvonen-Gutierrez, William H. Herman, Stuart Batterman, Siobán D. Harlow, Sung Kyun Park, "Urinary Metal Mixtures and Longitudinal Changes in Glucose Homeostasis: The Study of Women's Health Across the Nation (SWAN)" Feb. 2020.
4. Jiacong Du, Jonathan Boss, Lauren Beesley, Stephen Goutman, Stuart Batterman, Eva Feldman, Bhramar Mukherjee Variable selection with multiply-imputed datasets: choosing between stacked and grouped methods, *Statistics in Medicine*, submitted Mar. 2020.
5. Seo, Sung-Hee, Sung-Deuk Choi, Duk-Hee Lee, Yoon-Seok Chang, Influence of exposure to organochlorine pesticides on the Korean general population: 12-year trend and health effects, submitted Mar. 2020.
6. Tian Xia, James Catalan, Chris Hu, Stuart Batterman, Development of a Mobile Platform for Monitoring Gaseous, Particulate and Greenhouse Gas (GHG) Pollutants, submitted, Oct. 2020

Publications in Development

1. Batterman, Stuart A., D Giammar, A E DeDolph, P Schwer, A R H Putz, S McGinnis, V Snoeyink, E C Richter, "Effect of Household Water Consumption, Mains Replacement, and Water Meter Installations on Drinking Water Lead Levels"
2. Sung-Hee Seo, Sung-Deuk Choi, Duk-Hee Lee, Yoon-Seok Chang, Stuart Batterman, "Influence of exposure to organochlorine pesticides on the Korean general population: 12-year trend and health effects"
3. Nan Lin, Wei Li, Emily Meza-Wilson, Christopher Godwin, Marie-Anne Rosemberg, Stuart Batterman, "Occupational Exposure and Health Risks of Volatile Organic Compounds (VOCs) of Hotel Housekeepers", Feb. 2020.
4. Nan Lin, Emily Meza-Wilson, Christopher Godwin, Stuart Batterman, "Passive sampling of 1,4-Dioxane and analysis for soil vapor intrusion and other applications," submitted, 2020.

Peer-Reviewed Book Chapters and Proceedings (also see Conference Presentations for material after 2001)

5. **S. Batterman**, T. Dzubay, R.E. Baumgardner, D.L. Johnson, "Sampling and Analysis of Soil and Street Dust in the Philadelphia Area," Paper 87-14.2, proceedings of the Annual Meeting of the Air Pollution Control Association, New York NY, June 22, 1987.
6. J. Alcamo, **S. Batterman**, "Model Use." In: <u>The Regional Acidification and Information System Model,</u> J. Alcamo, ed., Reidell Press, 1989.
7. **S. Batterman**, "Measurements of Biogenic Emissions of Greenhouse Gases," proceedings of the International Conference on the Scientific and Policy Issues Facing All Governments, Chicago IL, April 9-12, 1990.
8. **S. Batterman**, A. Kulshrestha, "Contaminant Fluxes at Waste Sites and Landfills: Modeling Temporal and Spatial Variation," Paper 91-109.3, proceedings of the Annual Meeting of the Air and Waste Management Association, Vancouver Canada, June 1991.
9. **S. Batterman**, N. Bartoletta, H. Burge, "Fungal Volatiles of Potential Relevance to Indoor Air Quality," Paper 91-62.9, proceedings of the Annual Meeting of the Air and Waste Management Association, Vancouver Canada, June 1991.

10. **S. Batterman**, B. McQuown, "A Passive Soil Gas Flux Sampler: Laboratory and Field Evaluation," Paper 91.13-7, proceedings of the Annual Meeting of the Air and Waste Management Association, Vancouver Canada, June 1991.
11. **S. Batterman**, H. Shannon, "Estimating Emissions From Area Sources: Application of Direct and Indirect Approaches," Paper 91-86.4, proceedings of the Annual Meeting of the Air and Waste Management Association, Vancouver Canada, June 1991.
12. **S. Batterman**, "Identification of Pollution Sources in HVAC Systems Using Continuous Monitoring," proceedings of the Annual Meeting of the American Society of Heating, Ventilating and Air Conditioning Engineers, Denver CO, June 28, 1993.
13. **S. Batterman**, C. Peng, P. Milne, "Sequential Extractive Sampling of Indoor Air Contaminants using FTIR Spectroscopy," proceedings of the International Symposium on Optical Sensing for Environmental Monitoring, Air and Waste Management Association, Atlanta GA, Oct. 11-14, 1993.
14. **S. Batterman**, "Sampling and Analysis of Biological Volatile Organic Compounds." In: Bioaerosols, H.A. Burge, ed., CRC Press, Boca Raton, FL, 1995.
15. M. Baumann, **S. Batterman**, G. Zheng-Zhang, "Performance of a Chamber System for the Emission of VOCs from Wood Composites," presented at Wood Adhesives '95, Five Year Meeting of the Forest Products Society and the Forest Products Research Laboratory, Portland OR, June 29-30, 1995. Published in A.A. Christiansen and A.H. Conner, Eds., Wood Adhesives 1995, Forest Products Society, 215-219, 1996.
16. I. Ozak*, **S. Batterman**, C. Gelman, "Characteristics of Existing and Potential Filter Media for High-Volume Air Samplers," proceedings of the 89th Annual Meeting and Exhibition of the Air and Waste Management Association, Washington DC., June 23-28, 1996.
17. **S. Batterman**, A. Franzblau, "Breath, Urine and Blood Measurements as Biological Exposure Indices of Short-term Inhalation Exposures of Methanol," proceedings of the International Symposium on Biological Monitoring in Occupational and Environmental Health, Sept. 11-13, 1996, Espoo, Finland.
18. **S. Batterman**, N. White, "Exposures and Health Effects from a Large Sulfur Fire in South Africa," proceedings of the Air and Waste Management Association Annual Meeting, St. Louis, MO, July, 1999.
19. Y.L. Huang*, **S. Batterman**, "Sustained Rainfall and Drought: Statistical Analysis and Implications for Risk Assessment," proceedings of the Air and Waste Management Association Annual Meeting, St. Louis, MO, Paper 99-791, July, 1999.
20. C-Y Peng*, **S. Batterman**, "Quantification and apportionment of building, occupant and HVAC related emissions: Mass balance methods and applications," proceedings of Indoor Air 99, Edinburgh, Scotland, Aug. 8-13, 1999.
21. **S. Batterman**, So-Young Lin, Igor Osak, "Semi-Continuous Particle Mass Measurements for Indoor Applications: Development and Application," proceedings of Indoor Air 99, Edinburgh, Scotland, Aug. 8-13, 1999.
22. **S. Batterman**, A.T. Huang, L. Zhang, S. Wang, "Volatilization of Trihalomethanes during Storage and Consumption of Tap Water," proceedings of the Exposure Assessment for Disinfection By-Products in Epidemiological Studies International Workshop, May 7-10, 2000. Ottawa, Canada.
23. **S. Batterman**, J. Braun, C.Y. Peng, P. Warner, E. Butrym, "Exposure to Urban Air Toxics Exposures During Commuting: A Field Study in the Motor City," proceedings of the 93rd Annual Meeting and Exhibit of the Air and Waste Management Association, Salt Lake City, Utah, June 18-22, 2000.
24. E. Cairncross, **S. Batterman**, "Comparison of the Major Hazard Risk Management Approaches of the USA, the European Union, and South Africa," Paper 00-1053, proceedings of the 93rd Annual Meeting and Exhibit of the Air and Waste Management Association, Salt Lake City, Utah, June 18-22, 2000.
25. **S. Batterman**, C. Ziehl, C. Godwin, M. Gardell, Validation and Analysis of a Multipoint Monitoring System for Indoor Air Pollutants, proceedings of the NSF International Conference on Indoor Air Health, Miami, FL, Jan. 29-31, 2001.
26. P.J. Kalliokoski, M.M. Hyttinen, A-L. Pasanen, P.O. Pasanen, **S.A. Batterman**, "The Effect Of Air Humidity On The VOC Emissions From Loaded Ventilation Filters," proceedings of the NSF International Conference on Indoor Air Health, Miami, FL, Jan. 29-31, 2001.
27. Y.L. Huang*, **S. Batterman**, "Probability and Persistence of High Pollutant Concentrations in Soils: a Modeling Study and Implications on Exposure and Risk Assessment," proceedings of the Air and Waste Management Association Annual Meeting, Orlando, FL, July 2001.

28. T. Metts,* **S. Batterman**, P. Kalliokoski, E. Barnett, "Active and Diffusion Sampling of VOCs Using Thermal Desorption Tubes: Application at an Offset Printing Facility," proceedings of the International Symposium on Thermal Desorption in Occupational, Medicinal and Environmental Chemical Analysis, Birmingham AL (sponsored by U of Alabama, US Centers for Disease Control, and the US National Institute of Occupational Safety and Health, Oct. 9-10, 2001.

Peer-Reviewed Book Chapters

1. **S. Batterman**, Contributor to several chapters; Editor--Chapter 2 "Operating Principles." In: Hazardous Waste Incineration Calculations: Problems and Software, Reynolds, J., R. Dupont, L. Theodore, eds., J. Wiley and Sons, New York NY, 1990. .
2. **S. Batterman**, "Emergency Response to a Large Sulfur Fire." In: Teachers Guide for Environmental Health Applications, M. Weinger, ed., World Health Organization, 1998.
3. **S. Batterman**, "Environmental Impact Assessment", "Soil Contaminants, "Risk Assessment," and other extended entries. In: The Encyclopedia of Environmental Science, D.E. Alexander, R.W. Fairbridge, eds. Kluwar Academic Pub., Boston, 1999.
4. E. Parker, T.G. Robins, B.A. Israel, W. Brakefield-Caldwell, K.K. Edgren, A. O'Tolle, D. Wilkins, **S. Batterman**, T. Lewis, Developing and Implementing Guidelines for Dissemination: The Experience of the Community Action Against Asthma Partnership. in B.A. Israel, E. Eng, A.J. Schulz, E.A. Parker. Methods for Community-Based Participatory Research for Health, John Wiley, San Francisco, 2013.
5. **S. Batterman**, Evolution of Air Pollution Management in the USA: The Case of Detroit, Michigan., in Best practices of sustainability in metropolitan areas within the United States, Robert Brinkman, ed., University Press of Florida, in press, 2017.

Papers and Abstracts

Papers Delivered at Professional Meetings

1. **S. Batterman**, D. Golomb, "Predicting Maximum Pollutant Concentrations Using Joint Probabilities of Meteorological Variables," Joint Session on Probability and Statistics, presented at the American Meteorological Society Annual Meeting, Hot Springs AK, June, 1983.
2. **S. Batterman**, J.A. Fay, D. Golomb, "Incorporating Meteorological Data into Receptor Analysis," presented at the Air Pollution Control Association Specialty Conference on Receptor Methods for Source Apportionment, Williamsburg VA, March 12-14, 1985.
3. **S. Batterman**, J.A. Fay, D. Golomb, "The Significance of Regional Sources of Fine Particles," presented at the Annual Meeting of the Air Pollution Control Association, Minneapolis MN, June 14, 1986.
4. **S. Batterman**, M. Amann, J.P. Hettelingh, "Sulfur Emission Abatement Strategies Subject to Regional Deposition Target Levels in Europe," presented at the Annual Meeting of the Regional Science Association, Athens Greece, August 20, 1987.
5. P. Patel*, **S. Batterman**, "Movement of VOCs Through the Vadose Zone," poster presented at the Texas Water Pollution Control Association Annual Meeting, Austin TX, June 7-9, 1987.
6. **S. Batterman**, "Soil/Air Fluxes of Hazardous Substances at Treatment, Storage, and Disposal Facilities. Models and Measurements." Proceedings of the Gulf Coast Hazardous Substance Research Center Second Annual Symposium: Mechanisms and Applications of Solidification/Stabilization. Beaumont, TX, USA. 1990. *Journal of Hazardous Materials*; 24, 2-3, 304-305, Sept 1990.
7. N. Fogel*, **S. Batterman**, "Gravimetric Differential Reactor System to Measure Sorption Processes for VOCs in Soils," presented at the Bioremediation: Fundamentals and Effective Applications, Gulf Coast Hazardous Substances Research Center, Lamar University, Beaumont TX, February 21-22, 1991.
8. A. Kulshrestha*, **S. Batterman**, "Investigation of Processes Affecting Transport of VOCs in Soils," Bioremediation: Fundamentals and Effective Applications, presented at the Gulf Coast Hazardous Substances Research Center, Lamar University, Beaumont TX, February 21-22, 1991.
9. **S. Batterman**, "Comparison of Hydrocarbon Vapor Transport in Clean and Contaminated Soil Systems," poster presented at the American Geophysical Union Spring Meeting, Montreal Canada, May 12-14, 1992.

10. N. Pirrone*, **S. Batterman**, "Accumulation and Removal Processes of Persistent Pollution in Urban Areas, presented at the IAQPRC Conference on Diffuse Pollution: Sources, Prevention, Impact and Abatement," Chicago, IL, Sept. 20-24, 1993.
11. **S. Batterman**, "NIST Panel--International Organization of Legal Metrology--Performance Requirements for FTIR Spectrometers," presented at the International Symposium on Optical Sensing for Environmental Monitoring, Air and Waste Management Association, Atlanta GA, Oct. 11-14, 1993.
12. **S. Batterman**, "Indoor Air Quality in Large Office Buildings," presented to the Michigan Chapter, American Society of Heating, Ventilating and Air Conditioning Engineers, Lansing MI, Jan. 21, 1993.
13. **S. Batterman**, "Identification of Pollution Sources in HVAC Systems," presented at the Annual Meeting of the American Society of Heating, Ventilating and Air Conditioning Engineers, Chicago IL, Jan. 25, 1993.
14. A. Franzblau, **S. Batterman**, H. Xiao, E. Lee, R. Schreck, J. Darcy, J. Santrock, "Biological Monitoring of Exposure to Water-Soluble Compounds Using Alveolar Air," presented at the American Industrial Hygiene Association Conference, Anaheim CA, May 21-27, 1994.
15. E. Zellers, M. Han, S. Patrash, W. Groves, **S. Batterman**, "SAW Microsensor Arrays for Selective Real-time Measurements of Organic Vapors and Vapor Mixtures," presented at the American Industrial Hygiene Association Conference, Anaheim CA, May 21-27, 1994.
16. M.G.D. Baumann, **S. Batterman**, G-Z. Zhang, A.H. Conner "Design and Performance of a VOC Analysis System for Measuring Emissions from Wood Composites," Invited paper, presented at the Forest Products Society South-East Section, Annual Meeting and Workshop on E nvironmental Quality, Atlanta GA, Nov. 16-17, 1994. Published in R. Brinker, K. Muehlenfeld, B. Stokes, R.C. Tang, eds., Proceedings of the 1994 Forrest Products Society Southeastern Section Workshop on Environmental Quality in Wood Processing, Forest Products Society, Madison, WI, pp. 74-82, 1996.
17. **S. Batterman**, "Recommendations for FT-IR Spectrometers," presented at the International Symposium on Optical Sensing For Environmental and Process Monitoring, McLean VA, Nov. 7-10, 1994.
18. **S. Batterman**, H. Burge, "Emission Sources in HVAC Systems: A fl Review," Invited paper presented at the Annual Meeting of the American Society of Heating, Air Conditioning and Refrigeration Engineers, Chicago IL, Jan. 30, 1995.
19. **S. Batterman**, "NIST Panel--International Organization of Legal Metrology--Performance Requirements for FTIR Spectrometers," presented at the International Symposium on Field Screening Methods for Hazardous Wastes and Toxic Chemicals, EPA/Air and Waste Management Association, Las Vegas, NV, Feb. 24, 1995.
20. **S. Batterman**, "NIST Panel--International Organization of Legal Metrology--Performance Requirements for FTIR Spectrometers," presented at the Measurement of Toxics and Related Air Pollutants, EPA/Air and Waste Management Association, Durham, NC, May 16-18, 1995.
21. A. Franzblau, **S. Batterman**, C. Stephen, B. Nakfoor, J.B. D'Arcy, N.E. Sargent, K.B. Gross, R.M. Schreck, "Evaluation of Methanol and Formate in Urine as Biological Exposure Indices of Methanol Exposure," Paper 145, presented at the American Industrial Hygiene Conference, Kansas City, MO, May 20-26, 1995.
22. **S. Batterman**, "Role of Universities in Solving Environmental Problems," presented at the International Conference on The Egyptian Universities Research and Its Role in Solving Developmental and Environmental Problems, Al-Azhar University, Cairo, Egypt, July 17-20, 1995.
23. D.W. Bowman, J. M. Brannon, S.BATTERMAN, "Evaluation of Polychlorinated Biphenyl and Polycyclic Aromatic Hydrocarbon Concentrations in Two Great Lakes Dredged Material Disposal Facilities," presented at the Annual COE meeting, Detroit, MI, Oct. 1996.
24. **S. Batterman**, A. Franzblau, "Dermal Exposures and Uptake of Methanol: Model and Experimental Results," presented at the American Industrial Hygiene Conference and Exposition, Washington, DC, May 18-24, 1996.
25. **S. Batterman**, E. Cairncross, "A Dispersion Model of the AECI-Macassar Sulfur Fire Plume," presented at SAIChE '97, 8th National Meeting of the South African Institution of Chemical Engineers, Cape Town, South Africa, April 16-18, 1997.
26. S.L. Daniels, **S. Batterman**, M.A. Klemp, A. Wood, "Continuous Monitoring of Volatile Organic Compounds (VOCs) Affecting Indoor Air Quality in Laboratory and Industrial Environments," presented at the 29th Central Regional Meeting of the American Chemical Society, Midland, MI, May 27-30, 1997.

27. C-Y. Peng, **S. Batterman**, "Static Chamber Estimates of Sorption Parameters for HVAC Filters and Dust," poster presented at the 2nd Biennial Engineering Solutions to Indoor Air Quality, Research Triangle Park, NC, July 21-23, 1997.
28. S.L. Daniels, S.A. **Batterman**, M.A. Klemp, A. Wood, "Continuous Monitoring of Volatile Organic Compounds (VOCs) Affecting Indoor Air Quality in Laboratory & Industrial Environments," presented at the 2nd Biennial Engineering Solutions to Indoor Air Quality, Research Triangle Park, NC, July 21-23, 1997.
29. **S. Batterman**, A. Franzblau, H. Xiao, E. Lee, R. Schreck, J. Darcy, "Short-Term Inhalational Exposures To Methanol: Measurement of Clearance and Half-Life Using Biological Monitoring In Volunteers," presented at the American Industrial Hygiene Association Conference, Atlanta GA, April 13-18, 1998.
30. S.L. Daniels, **S. Batterman**, W.C. White, A. Wood, "Analysis Of Microbial Volatile Organic Compounds (MVOCs) In Indoor Air Environments Using High-Speed Gas Chromatography, Paper 1166, Session 145 on High Speed Gas Chromatography, PittCon '98, New Orleans, LA, March 5, 1998.
31. **S. Batterman**, L. Zhang, S. Wang, K. Mancy, "Disinfection By-Products in Drinking Water Systems," presented at NSF/EPA Conference on Drinking Water Small Scale Systems, Washington, DC., May 10-13, 1998.
32. S.L. Daniels, **S. Batterman**, W.C. White, A. Wood, "Applications of High-Speed Gas Chromatography in the Analysis of VOCs and MVOCs in Indoor Air Environments," 13th Annual International Symposium on the Measurement of Toxic and Related Air Pollutants, Cary, NC Sept. 1-3, 1998.
33. **S. Batterman**, E. Cairncross, "Ambient Air Monitoring and Air Pollution Management: A Comparison of National Strategies for Particulate Matter and Application to South Africa", presented at the 11th World Clean Air Congress, Durban, South Africa, Sept. 13-18, 1998.
34. L. Zhang*, **S. Batterman**, S. Wang, K. Mancy, "Reduction in Disinfectant By-Product Formation Using Chlorine as a Primary Disinfectant and a Silver-Hydrogen Peroxide Formulation a Secondary Disinfectant," presented at the 21st Midwest Environmental Chemistry Workshop, Ann Arbor, MI, Oct. 16-18, 1998.
35. J. Warila*, **S. Batterman**, "A Probabilistic Model for the Bioaccumulation of Silver in Aquatic Systems," presented at the 21st Midwest Environmental Chemistry Workshop, Ann Arbor, MI, Oct. 16-18, 1998.
36. J. Warila*, **S. Batterman**, "A Probabilistic Tropic Level Model for Silver Bioaccumulation in Aquatic Systems," presented at the 19th Annual Meeting, Society of Environmental Toxicology and Chemistry, Charlotte, NC, Nov. 15-19, 1998.
37. **S. Batterman**, "Evaluation of the Efficacy of a New Secondary Disinfectant Formulation Using Hydrogen Peroxide and Solver and the Formation of Disinfection By-Products Resulting from Interactions with Conventional Disinfectants, STAR Grants Drinking Water Program Review Meeting, Washington, DC, Dec. 8-9, 1998.
38. S. Armijo*, **S. Batterman**, A. Franzblau, C. Godwin, W. Baker, "A Review and Critique of Questionnaires in SBS-Type Investigations," poster presented at the 1st NSF International Conference on Indoor Air Health: Impacts, Issues, and Solutions, Denver, CO, May 3-5, 1999.
39. **S. Batterman**, "Health Risk Assessment at the Facility Level," 2nd International Workshop on Environmental Systems Analysis and Management, Ann Arbor, MI, Nov. 19-20, 1999.
40. **S. Batterman**, E. Cairncross, "Faculty, Curriculum and Research Development Related to Cleaner Production Technologies and Advanced and Smart Materials, presented at the Annual Research Meeting of the Tertiary Education Linkage Program, Pretoria, South Africa, April 2-5, 2000.
41. **S. Batterman**, "Air Sampling Using Sorbents and Short-Path Thermal Desorption," presented at the 48th American Society of Mass Spectroscopy Conference, June 11- 15, 2000, Long Beach, CA.
42. **S. Batterman**, "Experiences Teaching Risk Assessment," presented at the Annual Meeting of the Air and Waste Management Assoc., Salt Lake City June 18-22, 2000.
43. **S. Batterman**, "Evaluating The Health Effects of Indoor Air Mixtures," presented at the NSF International Conference on Indoor Air Health, Miami, FL, Jan. 29-31, 2001.
44. C.A. Bradlee*, **S. Batterman**, C.C. Godwin, "Assessing Pollutant Mixtures in Commercial Building Indoor Air," poster presented at Application of Technology to Chemical Mixtures, Annual Symposium on Mixtures, Colorado State University, Jan. 9-11, 2001.
45. **S. Batterman**., "Evaluation of the Efficacy of a New Secondary Disinfectant Formulation Using Hydrogen Peroxide and Silver and the Formulation of Disinfection By-Products Resulting From Interactions with Conventional

Disinfectants," presented at the US EPA Research Drinking Water Progress Review, Silver Spring, MD, Feb. 22-23, 2001.

46. **S. Batterman**, H. Bowles, B. Sun, "Progress in the UM-Pentech Tertiary Linkage Program, presented at the Global Partnership Meeting, UNCF, US AID Annual Meeting, Washington DC, April 2-4, 2001.
47. E.K. Barnett*, **S. Batterman**, P.J. Kalliokoski, T.A. Metts, C.A. Harms, "The Effect of Air Ionization and Area Ventilation on Indoor Air Quality at a Sheet-Fed Offset Lithographic Printing Facility," presented at the American Industrial Hygiene Conference & Expo, June 2 - 7, 2001, New Orleans, LA.
48. C. Ziehl*, **S. Batterman**, C. Godwin, M. Gardell, "Multipoint Monitoring and Assessment of CO_2, VOCs, NO_x and O_3 in an Office Building," presented at the American Industrial Hygiene Conference & Expo, June 2 - 7, 2001, New Orleans, LA.
49. C.A. Harms*, **S. Batterman**, E.K. Barnett, T. Metts, P. Kalliokoski, "Changes in Employee Perception at a Sheet-Fed Offset Lithographic Printing Facility Following Air Ionization and Area Ventilation," presented at the American Industrial Hygiene Conference & Expo, June 2 - 7, 2001, New Orleans, LA.
50. **S. Batterman**, "Linking Environmental Health Education to Engineering, Science, Economics and Management Using Spreadsheet (and other) Models," presented at the Environmental and Occupational Health Conference on Sustaining the Environmental Health Workforce, August 1-3, 2001, Seattle, WA.
51. **S. Batterman**, "Integration of MS and MPH Curricula in Environmental Health, Industrial Hygiene, Occupational Medicine, and Toxicology at the University of Michigan: A Risk-Based Approach," presented at the Environmental and Occupational Health Conference on Sustaining the Environmental Health Workforce, August 1-3, 2001, Seattle, WA.
52. T. Metts,* **S. Batterman**, P. Kalliokoski, E. Barnett, "Active and Diffusion Sampling of VOCs Using Thermal Desorption Tubes: Application at an Offset Printing Facility," presented at the International Symposium on Thermal Desorption in Occupational, Medicinal and Environmental Chemical Analysis, Birmingham AL (sponsored by U of Alabama, US Centers for Disease Control, and the US National Institute of Occupational Safety and Health, Oct. 9-10, 2001.
53. Chris Bradlee, **S. Batterman**, "Evaluation of Component-Based Chemical Mixtures Approaches for the Non-Cancer Health Risk Assessment of Indoor Air," presented at the 7th Annual Toxicology Research Symposium, University of Michigan, April 5, 2002, Ann Arbor, MI.
54. **S. Batterman**, T. Robins, G. Mentz, N. Bainjath, J Kistnasamy, "Air Pollution Exposure Measures for an Acute Epidemiological Study of Respiratory Effects in Children in Durban, South Africa," presented at the 12th Conference of the International Society of Exposure Analysis (ISEA); 14th Conference of the International Society for Environmental Epidemiology (ISEE), Aug. 11-15, 2002, Vancouver BC, Canada.
55. A-T Huang,* **S. Batterman**, "Formation of Trihalomethanes in Beverages and Foods," presented at the 12th Conference of the International Society of Exposure Analysis (ISEA); 14th Conference of the International Society for Environmental Epidemiology (ISEE), Aug. 11-15, 2002, Vancouver BC, Canada.
56. T. Robins, **S. Batterman**, G. Mentz, "Acute Symptoms And Disease Aggravation Among Primary School Students In Durban, South Africa Attributable To Air Pollution Exposures, presented at the 2nd Conference on Epidemiological Longitudinal Studies in Europe, June 12-14, 2002, Oulu, Finland.
57. **S. Batterman**, "Response and follow-up investigations related to a massive sulfur fire: A case study in disaster response and post-disaster evaluation," presented at Responding to a New Environment, Emergency Response at Schools of Public Health, ASPH, HRSA Conference, Pittsburgh, Sept. 9-10, 2002.
58. B. Hedgeman,* A. Sadeghnejad, J. Wirth, S Batterman, M Hultin, R Wahl, "The Impact of Maternal Exposure to Criteria Air Pollutants on Adverse Birth Outcomes: A Literature Review", presented at the Conference On Maternal Morbidity And Mortality, June 12, 2003, Lansing Michigan.
59. P. Kalliokoski, K. Owen, D. Leith, **S. Batterman**, "The predicted performance of activated carbon filtration for VOCs at indoor air concentrations, proceedings, The 7th International Symposium on Ventilation for Contaminant Control, Aug. 5-8, 2003, Sapporo, Japan.
60. A-T Huang,* **S. Batterman**, "Sorption of Trihalomethanes in Foods," 13th Conference of the International Society of Exposure Analysis (ISEA); Sept. 21-25, 2003, Stresa, Italy.

61. **S. Batterman,** Chris Godwin, Alfred Franzblau, Chunrong Jia, Swati Ellendula "VOC exposures among Among Teachers and Students in Schools and at Home," 13th Conference of the International Society of Exposure Analysis (ISEA); Sept. 21-25, 2003, Stresa, Italy.
62. **S. Batterman,** Chris Godwin, Alfred Franzblau, Chunrong Jia, Swati Ellendula, Richard Corsi, Vince Torres, Mark Sanders, "IAQ and Ventilation in Michigan and Texas Schools," 13th Conference of the International Society of Exposure Analysis (ISEA); Sept. 21-25, 2003, Stresa, Italy.
63. J. Kangas, J Laitinine, M Hautanmaki, M Hyttinen, P Pasanen, P Kalliokoski, **S Batterman**, "Solvent exposure in small offset plants," paper 117 presented at the American Industrial Hygiene Association Conference, May 8 – 13, 2003, Atlanta, GA.
64. **S. Batterman**, "Exposure Assessment in the Durban South Health Study," 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa, Feb. 23-27, 2004.
65. **S. Batterman**, "Risk Assessment in the Durban South Health Study," 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa, Feb. 23-27, 2004.
66. **S. Batterman**, "Review of Exposure Assessment in the Settlers School Study, Durban South Africa," 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa, Feb. 23-27, 2004.
67. *R. Naidoo, T. Robins, **S. Batterman**, "Epidemiological Approaches investigating the impact of environmental pollutants on health of communities in the Durban Metro." World Congress on Environmental Health, Durban, South Africa, Feb. 23-27, 2004.
68. Naidoo R, Robins T.G., C. Jack, E. Irusen, G.B. Mentz, U. Lalloo, J. Kistnasamy, S. Batterman. Results of the Settlers' School Study into environmental pollution and respiratory outcomes. World Congress on Environmental Health, Durban, 2004 (invited speaker)
69. **S. Batterman**, S.A., Yungdae Yu, Chunrong Jia, Christopher Godwin, "In-Use Evaporative Emissions from Vehicle Fuel Caps," Air & Waste Management Association Conference, Indianapolis, IN June 2004.
70. **S. Batterman**, C. Jia, Chris Godwin, Alfred Franzblau. "Sources and Significance of VOC Exposures in Microenvironments: Schools, Offices, Residences, Outdoors, and Vehicles," presented at the Air & Waste Management Association Conference, Indianapolis, IN June 2004.
71. Wahl, Robert, Alireza Sadeqnejad, Mary Lee Hultin, **S. Batterman**, Michael Depa, Julie Wirth, "Investigating Preterm Births and Air Pollution in Michigan," poster presented at the Environmental Public Health Tracking Conference, March 24-26, Philadelphia, PA.
72. **S. Batterman**, J. Dikos, J. Wirth, M.L. Hultin, M. Depa, R. Wahl, "Speciation of PM2.5 collected in two areas of Michigan," paper submitted to the International Society of Environmental Epidemiology Annual Meeting, August 1-4 2004, New York, NY.
73. Sadeqnejad Akireza, M.L. Hultin, **S. Batterman**, M. Depa, J. Wirth, R. Wahl, "Investigating Adverse Birth Outcomes and Air Pollution In Michigan," paper submitted to the International Society of Environmental Epidemiology Annual Meeting, August 1-4 2004, New York, NY.
74. **S. Batterman**, "Exposure Assessment in Environmental Epidemiology and Risk Assessment: Experiences on Three Continents," presented at the Michigan Department of Community Health, Lansing, MI, Sept. 16, 2004.
75. Van DerMerwe, **S. Batterman**, Y Gounden, "PM Collocation Study Conducted At Wentworth, South Durban in 2004" presented at National Association for Clean Air Conference, October 7-8, 2004, Johannesburg, South Africa.
76. Jia, Chunrong, **S. Batterman**, Chris Godwin, "Levels and Sources of VOC Exposures in Microenvironments: A Monte Carlo Analysis", Philadelphia, PA, International Society of Exposure Analysis Annual Meeting, October 17-21, 2004.
77. **S. Batterman**, "Strategies and Tools for Sustainable Development and Environmental Management," invited keynote speach presented at The Pacific Regional Symposium on Environmental Management and Occupational Health, Chung-Hwa College of Medical Technology, Tainan, Taiwan, November 4-6, 2004.
78. Bradlee, Christopher A., **S. Batterman**, ME Andersen, "Assessing the Toxicity of n-Hexane, Toluene and Acetone Mixtures Using an Interactions-adjusted Physiologically Based Toxicokinetic Model," Fall 2004 Meeting of the Michigan Regional Chapter of the Society of Toxicology, East Lansing, MI., Nov. 13, 2004.
79. **S. Batterman**, "Environmental Health, Sustainable Development and Environmental Management," presented at National Taiwan University, Nov. 8, 2004.

80. TG Robins, C. Jack, E. Irusen, G.B. Mentz, U. Lalloo, J. Kistnasamy, **S. Batterman**, R. Naidoo "High Prevalence of Bronchial Hyperreactivity among School Children in Durban, South Africa", ATS International Conference, San Diego, CA, May 22-25, 2005
81. A. Sadeqnejad, H. Lee, M.L. Hultin, **S. Batterman**, M. Depa, J. Wirth, D. Cornell, R. Wahl, "Adverse Birth Outcomes and Air Pollution in Michigan", Michigan Epidemiology Conference, Ann Arbor, MI, March 11, 2005.
82. *Hien Q Le, Alireza Sadeghnejad, Julia J. Wirth, Mary Lee Hultin, Michael Depa, **S. Batterman**, Robert L. Wahl, "Association of Ozone with Low Birth Weight in Southeast Michigan, 1990-2001," presented at the Annual Meeting of the Council of State and Territorial Epidemiologists, Albuquerque, NM, June 5 – 9, 2005.
83. *Hien Q Le.; **S. Batterman**; Alireza Sadeghnejad; Julia J. Wirth; Mary Lee Hultin; Michael Depa; Robert L. Wahl, "Association of ozone with low birth weight in Michigan, 1990-2001, using multiple imputation method for missing ozone values," 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
84. **S. Batterman**, C Jia, C Godwin, G Hatzivasilis, "Distributions of Volatile Organic Compounds (VOCs) in Indoor and Outdoor Air among Industrial, Urban and Suburban Neighborhoods," presented at IAQ 05, Beijing, China, Sept. 4-9, 2005.
85. ***C** Jia, **S. Batterman**, S Chernyak, "Development of a sensitive thermal desorption GC-MS method using selective ion monitoring for a wide range of VOCs," presented at IAQ 05, Beijing, China, Sept. 4-9, 2005.
86. **S. Batterman**, "Pollution, Health and Economic Development in South Durban," 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
87. ***Jafta** N., Gqaleni N., **Batterman S**., Naidoo R., Robins T. and Jia C., "Indoor air quality of selected residences in South Durban compared to north Durban." 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
88. ***Y.** Gounden, M. Van Der Merwe, **S. Batterman**, R. Naidoo, A. Mohamed, K. Govender, J. Chetty, "Exposure assessment in the Durban Health Study - conventional pollutants." 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
89. ***Jafta** N., Gqaleni N., **Batterman S**., Naidoo R., Robins T. and Jia C., "Indoor air quality of selected residences in South Durban compared to north Durban." 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
90. **S. Batterman**, C. Jia, S. Chernyak, Y. Gounden, "Exposure assessment for toxic air pollutants in Durban, South Africa," *Epidemiology*. 16(5): S129-S130, September 2005. Also presented at the 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
91. Robins, TG; **Batterman S**, Mentz GB, Kistnasamy J; Jack C, Irusen E, Lalloo U, Naidoo R, Kistnasamy B, Baijnath N, Amsterdam H, "Respiratory health and air pollution in South Durban: the Settlers School study," 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
92. Naidoo, R; **Batterman, S**; Robins, T.; Gqaleni, N.; Kistnasamy, J; Gounden, Y; Van der Merwe, M; Jack, C. "Overview of the Epidemiological and Health Risk Study conducted under the Multipoint Plan," 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
93. T.G. Robins, C. Jack, E. Irusen, G.B. Mentz, U. Lalloo, J. Kistnasamy, **S. Batterman**, R. Naidoo, "High Prevalence of Bronchial Hyperreactivity Among School Children In Durban, South Africa," International Conference of the American Thoracic Society, San Diego, CA, May 22 – 25, 2005.
94. Huang, AT, **Batterman S**, "Risk Assessment for Trihalomethanes in Beverages and Foods," Society for Risk Analysis (SRA) Annual Meeting, Orlando FL, December 4-7, 2005.
95. **S. Batterman**, C. Jia, G. Hatzivasilis, Simultaneous measurement of air exchange and VOC concentrations: application in vehicles, houses and garages, submitted to the Air & Waste Management Association 99th Annual Conference & Exhibition, New Orleans, LA June 20-23, 2006.
96. **S. Batterman**, C. Godwin, C. Jia., "Biological monitoring for VOCs," presented at Workshop on the Interpretation of Biomonitoring Data and their relationship to Exposure Information, American Chemistry Council, Minneapolis, MN, July 26-27, 2006.
97. **S. Batterman**, C. Jia, C. Godwin, G. Hatzivasilis, "A Dominant Source of VOC Exposure: Attached Garages," presented at the International Conference on Environmental Epidemiology & Exposure, Sept. 2-6, 2006, Paris, France.

98. Le, H; **S. Batterman**, K. Dombkowski, R. Walh, J. Wirth, E. Wasilevich, M. Depa, "A Comparison Of Multiple Imputation And Optimal Estimation For Missing And Uncertain Urban Air Toxics Data," presented at the International Conference on Environmental Epidemiology & Exposure, Sept. 2-6, 2006, Paris, France.
99. Jafta N, Gqaleni N, **Batterman S**, Naidoo R, Robins T. Allergen levels in the residences and schools in primary school children in Durban, Paper presented at the 3rd National Public Health Conference, Johannesburg, South Africa, May 16-17, 2006.
100. Sikhosana N, Jafta N, Gqaleni N, Naidoo R, **Batterman S**, Robins T. "Indoor concentration of particulate matter and carbon monoxide in the south and north of Durban." Paper presented at the 3rd National Public Health Conference, Johannesburg, South Africa, May 16-17, 2006. [*Nominated new researcher presentation*]
101. *Gounden Y, Batterman S, Naidoo R. "The Durban south Health study: Exposure monitoring." Poster presented at the 3rd National Public Health Conference, Johannesburg, South Africa, May 16-17, 2006.

    The preceding presentation received the Best New Researcher Poster Award.
102. Chernyak S, **Batterman S**, Gwynn E, Jia C, Begnoche L, "Temporal (1983-2005) and spatial trends of polybrominated diphenyl ethers in great lakes rainbow smelt and lake trout," to be presented at Dioxin 2006, Oslo, Norway, Aug. 21-5, 2006.
103. **S. Batterman**, S. Chernyak, Y Gounden, M Matooane, "Concentrations of persistent organic pollutants in ambient air in Durban, South Africa," to be presented at Dioxin 2006, Oslo, Norway, Aug. 21-5, 2006.
104. **S. Batterman**, C. Godwin, C. Jia, "Design and Evaluation of a New Breath Monitoring System for Volatile Organic Compounds," presented at the International Council of Chemical Association (ICC) Biomonitoring Workshop, Minneapolis, MN, July 26-7, 2006. Invited.
105. F. Freire, C.H. Antunes, M.C. Gameiro, **S. Batterman**, A.G. Martins, "Energy for sustainability (EfS): An initiative of the University of Coimbra, presented at the 10th meeting of the Alliance for Global Sustainability, Barecelona, Spain, March 18-21, 2007.
106. R. Poovendhree, R. Naidoo1, R. Naidoo, T.G. Robins, G. Mentz, S.J. London, **S. Batterman**, "Effect modification of respiratory responses to ambient air pollutants by GSTM1, GSTP1 and NQO1 polymorphisms," submitted to the American Thoractic Society International Conference, San Francisco, May 18-23, 2007.
107. **S Batterman**, S. Chernyak, W Wang, J Nriagu, "Organic and Metal Contaminants in Eurasian Caviar: Trends & Risks" SETAC Europe 17th Annual Meeting in Porto, May 20-24, 2007.
108. S Chernyak, **S. Batterman**, Y Youden, M. Matoonane, R. Naidoo, "Persistent and currently used pesticides in South African air, SETAC Europe 17th Annual Meeting in Porto, May 20-24, 2007.
109. S Chernyak, **S Batterman**, A Konoplev, A Kochetkov, C Godwin, C Jia, S Charles. "Fate of Brominated Flame Retardant Chemicals in Russian and US Buildings," SETAC Europe 17th Annual Meeting in Porto, May 20-24, 2007.
110. JY Chin, F Freire, J Malaca, **S Batterman**, "Incorporating local scale impacts into LCAs: Comparing conventional and ethanol fuels," SETAC Europe 17th Annual Meeting in Porto, May 20-24, 2007.
111. J Kistnasamy, TG Robins, **S Batterman**, G Mentz, R Naidoo, U Lalloo, E Irusen, C Jack. "The relationship between asthma and outdoor air pollution among primary school learners in Durban, South Africa," 4th International Conference on Children´s Health and the Environment, Vienna, Austria, June 10-12, 2007.
112. **S. Batterman**, "Management Systems for Health Care Waste. 1st Annual Infection Prevention and Control Meeting, Maputo, Mozambique. June 4, 2007.
113. N Jafta, N Gqaleni, R Naidoo, **S Batterman** and T Robins, "Characterization of biological pollutants (allergens and fungi) in low-to-medium income households in South Africa," Annual Meeting of the International Society for Environmental Epidemiology, Mexico City, Sept. 5-9, 2007.
114. Y. Gounden, **S. Batterman**, R. Naidoo, "Spatial and temporal trends of air pollutants in industrial and non-industrial communities," Annual Meeting of the International Society for Environmental Epidemiology, Mexico City, Sept. 5-9, 2007.
115. **S. Batterman**, Y. Gounden, R. Naidoo, S. Chernyak, T. Robins, "Exposures and health risks from toxic air pollutants in industrialized and non-industrialized communities," Annual Meeting of the International Society for Environmental Epidemiology, Mexico City, Sept. 5-9, 2007.

116. T. Robins, R. Naidoo, **S. Batterman**, G. Mentz, Y. Gounden, "Exposures and health risks from toxic air pollutants in industrialized and non-industrialized communities," Annual Meeting of the International Society for Environmental Epidemiology, Mexico City, Sept. 5-9, 2007.
117. **S. Batterman**, S. Chernyak, Y. Gounden, M. Matooane. "Concentrations of persistent organic pollutants in ambient air in Durban, South Africa," 27th International Symposium on Halogenated Persistent Organic Pollutants, Tokyo, Japan, Sept. 2-7, 2007.
118. **S. Batterman**, C. Jia, C. Godwin, "Determinants of VOC exposures and mixtures: Review of distributions of VOCs in indoor and outdoor air, factors affecting concentrations, and statistical analysis of high-concentration mixtures and their sources," International Society of Exposure Analysis (ISEA) 2007 Annual Meeting, Durham/Research Triangle Park, NC, October 14-18, 2007.
119. S. Chernyak, **S. Batterman**, E. Gwynn, C. Jia, L. Begnoche, "Temporal and Spatial Trends of Polybrominated Diphenyl Ethers in Great Lakes Rainbow Smelt and Lake Trout (1983-2005)", Dioxin 2007, 27th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Tokyo, Japan, Sept. 2-7, 2007.
120. S. Chernyak, **S. Batterman,** C.Godwin, C. Jia, S. Charles, "Evolution Of Flame Retardant Chemicals In A Newly Constructed Building, Dioxin 2007, 27th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Tokyo, Japan, Sept. 2-7, 2007.
121. Savinova T, **Batterman S**, Konoplev S, Savinov V, Gabrielsen GW, Alekseeva L, Kochetkov A, Pasynkova E, Samsonov D, Chernyak S, Koryakin A. "New environmental contaminants in seabirds from the Seven Islands Archipelago (Barents Sea, Russia)", Dioxin 2007, 27th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Tokyo, Japan, Sept. 2-7, 2007.
122. J-Y Chin, **S. Batterman**, "Alternative Fuels – Emissions, Permeability and Potential Health Impacts, Alliance for Global Sustainability Annual Meeting 2008, Cambridge, MA, Jan 29-31, 2008.
123. **S. Batterman**, C. Jia, C. Godwin, "Indoor and Outdoor Concentrations of VOCs and their Determinants in Industrial, Urban and Suburban Neighborhoods," Indoor Air 08, Copenhagen, Denmark, Aug. 17-22, 2008.
124. **S. Batterman S.**, C. Chernyak, C. Jia, C. Godwin, "Evolution of brominated flame retardant chemicals in dust, air and HVAC filters in a newly constructed multi-use building," Indoor Air 08, Copenhagen, Denmark, Aug. 17-22, 2008.
125. S. Chernyak Sergei, A Konoplev, **S Batterman**, A Kochetkov, E Pasynkova, D Samsonov, C. Jia, "PBDEs In Ambient and Indoor Air in Different Locations in the Russian Federation," Dioxin 2008, 28th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Birmingham, UK, Aug. 18-21, 2008.
126. **S Batterman**, S Chernyak, C Jia, S Charles, C Godwin, Trends and Mass Balance of Flame Retardant Chemicals in a New Building," Dioxin 2008, 28th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Birmingham, UK, Aug. 18-21, 2008.
127. K. Zhang, **S. Batterman** "Estimating on-road and near-road exposures due to traffic congestion," 2008 Joint Annual Conference of the International Society for Environmental Epidemiology and the International Society of Exposure Analysis, Pasadena, CA, Oct. 12-16, 2008.
128. Hien Le, **S Batterman**, A Sadeghnejad, R Wahl, J W, ML Hultin, M Depa, K Hoggatt, "Air pollutant exposure and preterm and small-for-gestational-age births in Detroit, Michigan: Long-term Trends and Associations," 2008 Joint Annual Conference of the International Society for Environmental Epidemiology and the International Society of Exposure Analysis, Pasadena, CA, Oct. 12-16, 2008.
129. Stevanovic A, J Stevanovic, K Zhang, **S Batterman**, "Optimizing Traffic Control to Reduce Fuel Consumption and Vehicular Emissions: Integrated Approach with VISSIM, CMEM, and VISGAOST (09-1707)," Presented at the 88th Annual Meeting of the Transportation Research Board, Washington DC., Jan. 11-15, 2009.
130. ML Hultin, HQ Le, **SA Batterman**, RL Wahl, JJ Wirth, MP Depa, "The Influence Of Air Pollutant De-trending On Analyses Of Exposure And Adverse Birth Outcomes," Annual Meeting of the Air & Waste Management Association, Detroit MI, June 14-19, 2009.
131. **Batterman S**, T Robins, R Wahl, T Lewis, E Wasilevich, ML Hulton, M Depa, F Dion, E Parker, J Wirth, A Vette, T Bruff, B Mukhergee, "Investigations of near-road health effects in Detroit – three epidemiological approaches," Annual Meeting of the Air & Waste Management Association, Detroit MI, June 14-19, 2009.
132. Kai Zhang, **Stuart Batterman**, "In-cabin Measurements of Traffic Related Air Pollutants in Ann Arbor, Michigan," Annual Meeting of the Air & Waste Management Association, Detroit MI, June 14-19, 2009.

133.Chunrong Jia, **Stuart Batterman**, Christopher Godwin, Simone Charles, Jo-Yu Chin, “Air Exchange Rates and VOC Sources in Offices and Other Industrial / Commercial Settings,” Annual Meeting of the Air & Waste Management Association, Detroit MI, June 14-19, 2009.

134.PI Johnson, Y Wang, TG Robins, RN Naidoo, GB Mentz, **SA Batterman**, C Jack, “Ambient Air Pollution and Decreased Lung Function in Children of Durban, South Africa,” Annual Meeting of the Air & Waste Management Association, Detroit MI, June 14-19, 2009.

135.**S Batterman**, J Bulkley, J Eisenberg, R Hardin, M Kruk, MC Lemos, A Michalak, B Mukherjee, E Renne , H Stein, C Watkins, M Wilson, “Sustainable Control of Water-Related Infectious Diseases: A Review and Proposal for Interdisciplinary Health-Based Systems Research,” Annual Conference of Universities Council on Water Resources, Chicago, IL, July 7-9, 2009.

136.**S Batterman**, C Jia, S Chernyak, C Godwin, “Concentrations and In-use Emissions of PBDEs from US Houses, Garages and Workplaces,” BFR2009 - 11th Annual Workshop on Brominated Flame Retardants, Ottawa, Canada, May 19-20, 2009.

137.MF Miller, SM Chernyak, SE Domino, **SA Batterman**, R Loch-Caruso, “Concentrations and speciation of polybrominated diphenyl ethers (PBDEs) in human amniotic fluid,” presented at Dioxin 2009, 29th International Symposium on Toxic Halogenated Persistent Organic Pollutants, Beijing China, Aug. 23-28, 2009.

138.AT Huang, KP Cantor, **S Batterman, “**Estimation for Reduced Trihalomethane Exposure through Ingestion from Heated Tea and Drinking Water,” International Society for Exposure Assessment, Annual Meeting, Dublin, Ireland, Aug. 24-29, 2009.

139.H. Elasaad, **S. Batterman**, “Polycyclic-Aromatic Hydrocarbons (PAHs) at Roadside Environments: Analysis of Ambient Air and Dry Deposition,” Poster presented at the American Society of Public Health Meeting, Philadelphia, PA, Nov. 7-10, 2009.

The preceding poster won a Student Achievement Award.

140.K. Zhang, **S.A. Batterman**, “Vehicle emissions in congestion: comparison of work zone and free-flow conditions,” Poster presented at the International Society of Exposure Assessment Conference, Minneapolis, MN, Nov. 1-5, 2009.

141.**S. Batterman**, “New Directions for Environmental Health: Healthy and Sustainable Homes, Workplaces and Cities. Keynote speech presented at the Healthy City and Environmental Health Conference, Seoul, Korea, Oct. 29-30, 2009.

142. A Vette, **S Batterman**, M Breen, V Isakov, S Perry, D Heist, G Norris, T Lewis, T Robins, F Dion, B Mukherjee, and the Community Action Against Asthma Steering Committee. “Impact of mobile sources on near-roadway exposures and respiratory effects for childhood asthmatics.” Poster presented at the American Association for Aerosol Research Specialty Conference – Air Pollution and Health: Bridging the Gap from Sources to Health Outcomes, San Diego, March 22 – 26, 2010.

143.**S Batterman**, B Mukherjee, F-C Su, C Jia, JC D’Souza, “Modeling and Analysis of Personal Exposure to Pollutant Mixtures: Further Analysis of the RIOPA Data,” Invited poster presented at the Health Effects Institute Annual Meeting, Alexandria, VA, April 25-27. 2010.

144.T.C. Lewis, T.G. Robins, **S.A. Batterman**, E.A. Parker, W. Brakefield-Caldwell, et al. “Recruitment Design for a Study of Health Effects of Diesel Exhaust Among Children with Asthma: A Blend of Geographic Information Systems and Community-Based Participatory Research Methods,” American Thoracic Society International Conference, New Orleans, May 14-19, 2010.

145.A Konoplev, S Batterman, S Chernyak, A Kochetkov, E. Pasynkova, D Samsono, “PBDEs in ambient air of Russian cities and their gradient in direction from Moscow to the Arctic,” to be presented at the International Polar Year Oslo Science Conference, June 8-12, 2010, Oslo, Norway.

146.S Chernyak, **Batterman S**, N Basu, S Bohac, W. Northrop. “PAHS, nitro-PAHs & diesel exhaust toxins in the Great Lakes,” presented at Dioxin 2010, 30th International Symposium on Toxic Halogenated Persistent Organic Pollutants, San Antonio, TX, Sept. 12-17, 2010.

147.Howard Hu, Martin Philbert, Bruce Richardson, Raymond Yung, Rita Loch-Caruso, Toby Lewis, Vasantha Padmanabhan, Dana Dolinoy, **Stuart Batterman**, John Meeker, Karen Peterson, Olivier Jolliet, Steven Gruber, , Robert Lyons, Laura Rozek, Daniel McConnell, Cathy Spino, Marie O'Neill, Roderick Little, Bhramar Mukherjee, Brisa Sanchez, Maureen Sartor, Gil Omenn, Amy Schulz, Barbara Israel, Niladri Basu. "The UM NIEHS P30 Core

Center: Lifestage Exposures and Adult Disease." Poster presented at the Symposium on Epigenetics, University of Michigan, Sept. 23, 2010.

148. L Du, **S Batterman**, Edith Parker, Christopher Godwin, Jo-Yu Chin, Ashley O'Toole, Thomas Robins, Toby Lewis, Wilma Brakefield. "Use and impact of free-standing air filters placed in bedrooms of children with asthma in Detroit, Michigan: Community Action Against Asthma", accepted, 2010 ASPH Annual Meeting, Denver, CO, Nov. 6-10, 2010.

149. Parker, EA, Chung, L., Keirns, C., Strong, L., Israel, BA, Robins, TG, **Batterman, S**., Brakefield-Caldwell, W., Wilson, C., Mentz, G, Lewis, TC "Exploring the Relationship between Physical and Social Environmental Factors and Asthma Exacerbation in Children: Results of the Community Action Against Asthma Baseline Survey," accepted, 2010 ASPH Annual Meeting, Denver, CO, Nov. 6-10, 2010.

150. Matooane M, Naidoo R, **S. Batterman** "Time activity patterns: a case of south Durban, South Africa" presented at the 2010 Joint Conference of International Society of Exposure Science & International Society for Environmental Epidemiology, Seoul, Korea, 28 August 1 September, 2010.

151. **S Batterman**, Jo-Yu Chin, Chunrong Jia, Christopher Godwin, Edith Parker, Thomas Robins, Paul Max, Toby Lewis. "Review And Update Of Naphthalene Exposures - Is This The Highest Risk VOC?", Paper presented at Indoor Air 2011, June 5-10, 2011, Austin, TX.

152. **S Batterman**, Alan Vette, Gary Norris, Jon Thornburg, Jeff Portzer, Tom Robins, Toby Lewis, Community Action Against Asthma Steering Committee. "Traffic-Related Exposures of Children With Asthma Living Near Highways: A Seasonal Assessment Including Indoor and Outdoor Trends of Black Carbon, $PM_{2.5}$ and Other Pollutants", poster presented at Indoor Air 2011, June 5-10, 2011, Austin, TX.

153. Liuliu Du, **Stuart Batterman**, Edith Parker, Christopher Godwin, Jo-Yu Chin, Ashley O'Toole, Thomas Robins, Wilma Brakefield-Caldwell, Zachary Rowe, Toby Lewis, " Free-Standing Air Filters in Bedrooms of Inner City Children With Asthma. Do They Make A Difference?", Paper presented at Indoor Air 2011, June 5-10, 2011, Austin, TX.

154. Chunrong Jia, **Stuart Batterman**, Feng-Chiao Su, "Modeling Exposures to Indoor Air Pollutant Mixtures: Application of Copula Methods to the RIOPA Data," presented at Indoor Air 2011, June 5-10, 2011, Austin, TX.

155. Ashley O'Toole, A, Parker E, **Batterman S**, Robins T, Du L, Godwin C, Grant S, Rowe, Z, Lewis TC, and the Community Action Against Asthma Steering Committee. "Factors Affecting Air Filter Usage in Homes of Children with Asthma In Detroit, MI." Presented at the American Thoracic Society International Conference, Denver, CO, May 13-18, 2011.

156. Lewis TC, Parker EA, Robins TG, **Batterman S**, Mukherjee B, Mentz GB, Ren X, Godwin C, O'Toole AM, Grant S, and the Community Action Against Asthma Steering Committee. "Suitability of Homes of Asthmatic Children In Detroit for Installation of Window Unit Air Conditioners." Presented at the American Thoracic Society International Conference, Denver, CO, May 13-18, 2011.

157. Lewis TC, Robins TG, **Batterman S**, Mukherjee B, Mentz GB, O'Toole AM, Brakefield-Caldwell W, Grant S, Parker EA, and the Community Action Against Asthma Steering Committee. "Baseline Demographic And Health Characteristics Of A Cohort Of Urban Asthmatic Children By Proximity Of Residence To Highways". Submitted to the American Thoracic Society International Conference, Denver, CO, May 13-18, 2011.

158. F-C Su, **S Batterman**, B Mukherjee, C Jia, JC D'Souza, "Modeling and Analysis of Personal Exposure to Pollutant Mixtures: Further Analysis of the RIOPA Data including Extreme Value Distributions and Factor Analyses of Pollutant Data, Invited poster presented at the Health Effects Institute Annual Meeting, Boston, MA, May 1-3, 2011.

159. Davyda Hammond, **Stuart Batterman**, Gary Norris, Alan Vette, Michael Breen, Janet Burke, Vlad Isakov, Toby Lewis, and the Community Action Against Asthma Steering Committee, "Impact of Mobile Sources on Near-Roadway Exposures and Respiratory Effects for Children with Asthma" Invited poster presented at the Health Effects Institute Annual Meeting, Boston, MA, May 1-3, 2011.

160. **Stuart Batterman**, "Recent and Ongoing Studies of Air Pollutants and Asthma among Children in Detroit," Invited keynote speaker, Asthma Initiative of Michigan (AIM) Partnership Forum, Michigan Department of Community Health, Lansing, MI, May 10, 2011.

161. **S. Batterman**, S Chernyak, P Mochungong. Persistent organic pollutants in bottom ash from hospital waste incineration and adjacent soils in Africa, Presented at Dioxin 2011, August 21-25, Brussels, Belgium.

162.**Stuart Batterman**, Liuliu Du, Edith Parker, Christopher Godwin, Ashley O'Toole, Thomas Robins, Jie Zhou, Community Action Against Asthma, and Toby Lewis, "An intervention study using free-standing HEPA air filters and air conditioners placed in bedrooms of inner city children with asthma." Platform presentation at the International Society of Environmental Epidemiology Annual Meeting, Barcelona, Spain, Sept. 13-16, 2011.

163.**S Batterman**, S Li, S Sangameswaran, B Mukherjee, A Ekstrom, T Robins, P Hopke, S Raja, T Lewis, "Traffic-related exposures and health outcomes of children with asthma living both near and far from highways." Poster presented at the International Society of Environmental Epidemiology Annual Meeting, Barcelona, Spain, Sept. 13-16, 2011.

164.TC Lewis, LS. Rozek, A VanZommeren-Dohm, B Mukherjee, X Ren, GB Mentz, TG Robins, E Hughes, LN Doan, **S Batterman,** and Community Action Against Asthma Steering Committee. "Characterization of Global DNA Methylation at LINE-1 in a Cohort of Urban Asthmatic Children with a Gradient of Exposure to Highways" Poster presented at the International Society of Environmental Epidemiology Annual Meeting, Barcelona, Spain, Sept. 13-16, 2011.

165.Lei Huang, Stanislav V. Bohac, Jo-Yu Chin, Sergei Chernyak, and **Stuart A. Batterman**. "Effect of fuel composition on PAH and nitro-PAH emissions from diesel engines. Poster presented at the 21st Annual International Society of Exposure Science (ISES) conference, Baltimore, Maryland, USA. October 23 - 27, 2011.

166.**Stuart A. Batterman**, Jo-Yu Chin, Stanislav V. Bohac, Lei Huang, Sergei Chernyak, and Dennis N. Assanis. "Dependence of Diesel Engine Exhaust Markers on Fuel Type." presented at the 21st Annual International Society of Exposure Science (ISES) conference, Baltimore, Maryland, USA. October 23 - 27, 2011.

167.**Stuart A. Batterman**, "Near Roadways Exposure to Urban Air Pollutants Study (NEXUS) - Health Effects Measurements and Analyses Update," Invited seminar and Webinar presented at the START Grants Progress Review Meeting, US EPA, Research Triangle Park, March 28-29, 2012.

168.T. Lewis, L Doan, T Robins, S Batterman, B Mukherjee, G Mentz, X Ren, S Grant, E Parker, "Asthma Control In Detroit Children Is Associated With Exposure To Highway Traffic." to be presented at the American Thoractic Society International Conference, May, 2012.

169.Feng-Chiao Su, Shi Li, Bhramar Mukherjee, Stuart A. Batterman, "Analysis of Personal Exposures in the RIOPA Study: Extreme Value, Mixture, and Dirichlet Process Models", poster presented at the Health Effects Institute Annual Conference, Chicago, IL. 15-17 April, 2012.

170.A. Mendes, C. Pereira, D. Mendes, L. Aguiar, F. Guimarães, M. Botelho, M.P. Neves, **S. Batterman**, J.P Teixeira, Indoor air quality and thermal comfort -- Results of a pilot study in elderly care centers in Portugal, presented at the second International Congress on Environmental Health, Lisbon, Portugal, May 29-June 1, 2012.

171.**Stuart A. Batterman**, "Workshop on approaches to improve assessment of exposure to traffic-related pollutants," poster presented the Health Effects Institute, Chicago, IL, April 18, 2012.

172.Ana Mendes, Lívia Aguiar, Diana Mendes, Susana Silva, Cristiana Pereira, Mónica Botelho, Paula Neves, Stuart Batterman, João Paulo Teixeira. "GERIA Project – Indoor Air and Quality of Life in Elderly Care Centres" paper presented at Healthy Buildings 8, Brisbane, Australia, 8 - 12 July 2012.

173.Janet Burke, Ali Kamal, Sarah Bereznicki, Kathie Dionisio, Ram Vedantham, Carry Croghan , Matthew Landis, Gary Norris, Alan Vette, **Stuart Batterman**, Community Action Against Asthma. "Variability in exposures to traffic-related air pollutants across Detroit in the Near-Road Exposures and Effects of Urban Air Pollutants Study (NEXUS)". Presented at the International Society of Exposure Science (ISES) conference, Seattle, WA. October 28-November 1, 2012.

174.**Stuart Batterman**, Liuliu Du, Christopher Godwin, Jo-Yu Chin, Thomas Robins, Toby Lewis, Community Action Against Asthma. "Concentration gradients in residences with strong pollutant sources and air filters -- melding field study data and models to understand exposure." Presented at the International Society of Exposure Science (ISES) conference, Seattle, WA. October 28-November 1, 2012.

175.Michael Breen, James Crooks, Thomas Long, Bradley Schultz, Miyuki Breen, John Langstaff, Kristin Isaacs, Cecilia Tan, Ronald Williams, Ye Cao, Robert Devlin, **Stuart Batterman**, Martha Sue Carraway, "GPS-based Microenvironment Tracker (MicroTrac) to Estimate Time-Location Profiles for Individuals in Health Studies." Presented at the International Society of Exposure Science (ISES) conference, Seattle, WA. October 28-November 1, 2012.

176.*Lei Huang, Sergei Chernyak, **Stuart A. Batterman**, "PAHs, Nitro-PAHs, Hopanes and Steranes in Lake Trout from Lake Michigan", Poster presented at the SETAC North America 33rd Annual Meeting, Long Beach, CA, 11-15 November 2012.

177.*M Bradley, L Huang, J Rutkiewicz, K Mittal, J Head, S Chernyak, **S Batterman**, N Basu, "In ovo exposure to 1-nitropyrene: Developmental, biochemical and behavioral changes in white leghorn chicken hatchlings." Poster presented at the SETAC North America 33rd Annual Meeting, Long Beach, CA, 11-15 November 2012.

178.*Peter Dornbos, Sean Strom, Tom Cooley, Sergei Chernyak**, Stuart Batterman** and Niladri Basu. "Polybrominated Diphenyl Ethers in Wisconsin River Otters and Michigan Bald Eagles" Paper presented at the SETAC North America 33rd Annual Meeting, Long Beach, CA, 11-15 November 2012.

179.Michael Breen, Janet Burke, **Stuart Batterman**, Alan Vette, Gary Norris, Christopher Godwin, Matthew Landis, CAAA, Carry Croghan, Thomas Long, Miyuki Breen, Bradley Schultz. "Air Pollution Exposure Model for Individuals (EMI) in Asthma Health Study: Predicting Air Exchange Rates for Residences in Detroit, Michigan", Presented at the Annual Meeting of the Society of Toxicology, San Antonio, TX, March 10-14, 2013.

180.Michelle Snyder, Vlad Isakov, Janet Burke, Alan Vette, Sarav Arunachalam, **Stuart Batterman**, "Applying Multi-scale Air Quality Models to Support Epidemiologic Studies," Clean Air Research Center Meeting, US Environmental Protection Agency, Research Triangle Park, NC, July 22, 2013.

181.João Carrilho, **Stuart Batterman**, Manuel Gameiro da Silva. "Estimating Time Varying Air Exchange Rates." submitted to the REHVA World Congress and 8th International Conference on IAQVEC, Prague, Czech Republic, June 16-19, 2013.

182.V. Isakov, Michelle Snyder, David Heist, Steven Perry, Janet Burke, Sarav Arunachalamy**, Stuart Batterman**, Rajiv Ganguly, and CAAA. "Development Of Model-Based Air Pollution Exposure Metrics For Use In Epidemiologic Studies." Submitted to the 33rd NATO/SPS International Technical Meeting (ITM) on Air Pollution Modeling and Its Applications, August 26-30, 2013 Miami, FL.

183. João Carrilho, Manuel Gameiro da Silva, **Stuart Batterman**, "Instantaneous air exchange rates from tracer gas profiles", to be presented at Mediterranean Congress of Air Conditioning (CLIMAMED), Istanbul, Turkey, Oct. 3--4, 2013.

184.**Stuart Batterman**, Thomas Robins, Toby Lewis, Rajiv Ganguly, Michael Breen, Janet Burke, Vlad Isakov, Michelle Snyder, Erminia Ramirez, Wilma Brakefield-Caldwell. "Improving Exposure Estimates for Traffic-Related Air Pollutants." Platform presentation at the Air & Waste Management Association Annual Conference & Exhibition, Chicago, IL, June 25-28th, 2013.

185.*Rajiv Ganguly, **Stuart Batterman**, Michelle Snyder, Vlad Isakov. Geocoding and Exposure Errors for Residences near Highways: Application of AERMOD in Detroit, Michigan. Platform presentation at the Air & Waste Management Association Annual Conference & Exhibition, Chicago, IL, June 25-28th, 2013.

186.Michelle Snyder, Sarav Arunachalam, Vlad Isakov, David Heist, **Stuart Batterman**, Kevin Talgo, Rajiv Ganguly, Paul Harbin. Sensitivity Analysis of Dispersion Model Results in the NEXUS Health Study due to Uncertainties in Traffic-related Emissions Inputs. Platform presentation at the the Air & Waste Management Association Annual Conference & Exhibition, Chicago, IL, June 25-28th, 2013.

187.Sarah D. Bereznicki, Janet Burke, Kathie Dionisio, Carry Croghan, **Stuart Batterman**. A Multi-pollutant Evaluation of Traffic Exposure Classes Used in the Near-Road Exposures and Effects of Urban Air Pollutants Study (NEXUS). Platform presentation at the Air & Waste Management Association Annual Conference & Exhibition, Chicago, IL, June 25-28th, 2013.

188.Michelle Snyder, Sarav Arunachalam, Vlad Isakov, David Heist, Janet Burke, Sarah Bereznicki, Kathie Dionisio, **Stuart Batterman**, and Paul Harbin. "Applying Multi-scale Air Quality Models to Support Epidemiologic Studies." Poster 4191 to be presented at the Environment and Health – Bridging South, North, East and West. Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.

189.Michael Breen, Janet Burke, **Stuart Batterman**, Alan Vette, Gary Norris, Christopher Godwin, Matthew Landis, Carry Croghan, Thomas Long, Bradley Schultz, Wilma Brakefield. "Air Pollution Exposure Model for Individuals (EMI) in Asthma Health Study: Predicting Air Exchange Rates for Residences in Detroit, Michigan." Platform presentation at the the Environment and Health – Bridging South, North, East and West. Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.

190. Nichole Baldwin, Philip Hopke, **Stuart Batterman**, Suresh Raja, Thomas Robins, "Spatial-Temporal Variation of Pollutants in the Near-Road Environment." submitted to the Environment and Health – Bridging South, North, East and West. Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.
191. Rajiv Ganguly, **Stuart Batterman**, Vlad Isakov, Michelle Snyder, Thomas Robins, Toby Lewis, Paul Harbin. "A new approach for maintaining anonymity and enhancing robustness of model-based personal exposure estimates." submitted to the Environment and Health – Bridging South, North, East and West. Poster 4430 presented at the Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.
192. Rajiv Ganguly, **Stuart Batterman**, Vlad Isakov, Michelle Snyder, Thomas Robins, Toby Lewis, Paul Harbin. " Participant Use of Free-Standing Filters in an Asthma Intervention Study." Platform presentation 4420 presented at the Environment and Health – Bridging South, North, East and West. Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.
193. Joana Bastos, **Stuart Batterman**, Fausto Freire. Comparative life-cycle analysis of residential typologies in lisbon, Portugal: an apartment building and two semi-detached houses. Presented at Energy for Sustainability 2013, Coimbra, Portugal, 8 to 10 September, 2013.
194. Stuart Batterman, Rajiv Ganguly, Vlad Isakoff, Janet Burke, Saravanan Arunachalam, Michelle Snyder, Tom Robins, Toby Lewis, "Dispersion Modeling of Traffic-Related Air Pollutants: Exposure and Health Effects among Children with Asthma in Detroit, Michigan." Poster presented at the Transportation Research Board (TRB) 93rd Annual Meeting, Washington, DC, January 12-16, 2014.
195. M. Breen, J. Burke, **S. Batterman**, A. Vette, G. Norris, C. Godwin, M. Landis, C. Croghan, B. Schultz, M. Breen. Air Pollution Exposure Model for Individuals (EMI) in Health Studies: Predicting Spatiotemporal Variability of Residential Air Exchange Rates. Poster presented at the Annual Society of Toxicology Meeting, Phoenix, AZ, March 23-27, 2014.
196. Stuart A. Batterman, Veronica J Berrocal, Saravanan Arunachalam, K. Max Zhang, Gisselle Kolenic. "Integrating enhanced models and measurements of traffic-related air pollutants for epidemiological and risk studies using Bayesian Melding." Invited poster to be presented at the 2014 Health Effects Institute Annual Conference, May 4-6, 2014, Alexandria, VA, USA.
197. Sergei Chernyak, **Stuart Batterman**. "Measuring Persistent Organic Pollutants in Newborn Blood Spots: Performance and Stability of Brominated Flame Retardants, PCBs, and Halogenated Pesticides." SETAC Europe 24th Annual Meeting in Basel, Switzerland, 11-15 May, 2014, Basel, Switzerland.
198. **S. Batterman**, Chernyak S. "Performance and Integrity of Blood Spot Measurements of BFRs, PCBs and Halogenated Pesticides," Presented at the 14th Annual Workshop on Brominated & Other Flame Retardants (BFR), Indianapolis, IN June 22-24 2014.
199. Lewis, T., T. Robins, **S. Batterman**, B. Mukherjee, G. Mentz, X. Ren, E. Parker, E Ramirez, "Association of Highway Traffic and Lung Function Among Children with Asthma in Detroit", presented at the International Society of Environmental Epidemiology meeting, Aug. 24-28, 2014, Seattle, WA.
200. Feng-Chiao Su, **Stuart Batterman**, Brian Callaghan, Eva Feldman. "Amyotrophic Lateral Sclerosis (ALS), Occupational Risk Factors and Exposure Windows: A Case-Control Study in Michigan." presented at the International Society of Environmental Epidemiology meeting, Aug. 24-28, 2014, Seattle, WA.
201. Vlad Isakov, David Heist, Janet Burke, Michelle Snyder, Sarav Arunachalam, **Stuart Batterman**. "Hybrid Air Quality Modeling Approach for use in the Near-road Exposures to Urban air pollutant Study (NEXUS)." Submitted to the 16th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 8-11 September 2014, Varna, Bulgaria.
202. **S. Batterman**, Sarah Chambliss, "Exposure Assessment and Misclassification for Traffic-Related Air Pollutants Using Census Information: Spatial Resolution Needs". Presented at the the 2014 annual meeting of International Society of Exposure Science, Cincinatti, OH, Oct. 12-16, 2014.
203. J. Burke, G. Norris, S. Bereznicki, C. Croghan, A. Russell, S. Brown, **S. Batterman**, "Variability in source impacts for residential indoor and outdoor PM2.5 in NEXUS homes." Presented at the 2014 annual meeting of International Society of Exposure Science, Cincinatti, OH, Oct. 12-16, 2014.

204. M. Breen, J. Burke, **S. Batterman**, A. Vette, G. Norris, C. Godwin, M. Landis, C. Croghan, V. Isakov. "Exposure Modeling of Residential Air Exchange Rates for NEXUS Participants," Presented at the 2014 annual meeting of International Society of Exposure Science, Cincinatti, OH, Oct. 12-16, 2014.
205. V. Isakov, D. Vlad, J. Burke, K. Dionisio, S. Bereznicki, M. Snyder, S. Arunachalam, **S. Batterman**. Air Quality Modeling of Traffic-related Air Pollutants for the NEXUS Study. Presented at the 2014 annual meeting of International Society of Exposure Science, Cincinatti, OH, Oct. 12-16, 2014.
206. **S. Batterman**, T. Stuart, T. Lewis, T. Robins, G. Mentz, V. Isakov, J. Burke. "Using modeled estimates of exposure to traffic-related air pollutants to identify respiratory health impacts for the NEXUS cohort." Presented at the 2014 annual meeting of International Society of Exposure Science, Cincinatti, OH, Oct. 12-16, 2014.
207. João Carrilho, Manuel d'Silva. **Stuarty Batterman**, "Measurement of infiltration rates from daily cycle of ambient CO_2", Presented at the 35th AIVC – 4th TightVent – 2nd Venticool Conference, Poznan, Poland, Sept. 24-25, 2014.
208. Stuart A. Batterman, Veronica J Berrocal, Saravanan Arunachalam, K. Max Zhang, Owais Galanni, "Integrating enhanced models and measurements of traffic-related air pollutants for epidemiological and risk studies using Bayesian Melding." Invited poster, presented at the 2015 Health Effects Institute Annual Conference, May 3-5, 2015, Philadelphia, PA, USA.
209. **S. Batterman**, "Emerging Health and Safety Issues in the Petrochemical Industry: A Life Cycle Perspective," invited keynote speach presented at International Conference of Industrial Hygiene & Occupational Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan, Apr. 25~26, 2015.
210. João Carrilho, M. Mateus, **Stuart Batterman,** Manuel d'Silva. **"**Using periodic variation of outoor gases to measure the infiltration rates of buildings, submitted to ISIAQ Healthy Buildings, Eindhoven, The Netherlands, May 18-20, 2015.
211. **Stuart Batterman**, Luilui Du, Christopher Godwin, Zachary Rowe, Jo-Yu Chin, "Air exchange rates and migration of VOCs in basements and residences," presented at ISIAQ Healthy Buildings, Eindhoven, The Netherlands, June 18-20, 2015.
212. João Carrilho, M. Mateus, **Stuart Batterman,** Manuel d'Silva, The effect of diffusion on tracer gas method measurements of air exchange rates. Presented at the 36th Air Infiltration and Ventilation Centre Conference, Madrid, Spain, Sept. 23-24, 2015.
213. João Carrilho, M. Mateus, **Stuart Batterman,** Manuel d'Silva. Further developments on the atmospheric tracer gas technique for measuring AERs. Presented at the 36th Air Infiltration and Ventilation Centre Conference, Madrid, Spain, Sept. 23-24, 2015.
214. Schulz, A.J., **Batterman, S**., Reyes, A.G., Rice, K.L., Williams, G., Community Action to Promote Healthy Environments: Creating a Public Health Action Plan to Translate Research to Action and Policy Change. Presented at the American Public Health Association Annual Meeting, Chicago, IL, Oct. 31-Nov. 4, 2015.
215. Janet Burke, Vlad Isakov, Michael Breen, **Stuart Batterman**. "Modeling exposures to traffic-related air pollutants for the NEXUS respiratory health study of asthmatic children in Detroit, MI. Presented at the International Society of Exposure Science Conference, Henderson, NV, Oct. 18-23, 2015.
216. Stuart Batterman, Guy Williams, Amy Schulz, Kristina Rice, Sheena Martenies, Larrisa Larson, "Moving Research to Action to Reduce Adverse Health Effects of Air Pollution: Community Action to Promote Healthy Environments (CAPHE)," Presented at the 20th Anniversary Detroit Urban Research Center Symposium, Detroit, MI, Jan. 21, 2016.
217. Kristina Rice, **Stuart Batterman**, Amy Schulz, "Community Action to Promote Health Environments (CAPHE): "Working Together to Improve Detroit's Air." Poster presented at the 20th Anniversary Detroit Urban Research Center Symposium, Detroit, MI, Jan. 21, 2016.
218. Joana Bastos, **Stuart Batterman** and Fausto Freire, "How does residential location influence the environmental life-cycle impacts of a household?". Presented at UAHS World Congress on Housing, Dec. 16-19, 2015, Funchal, Portugal.
219. Chad Milando, Lei Huang, **Stuart Batterman, "**Pollutant sources affecting Air Quality in Detroit," Presented at the 21st Annual Environmental Health Sciences Symposium, School of Public Health, Ann Arbor, MI, Jan. 22, 2016.
220. Sheena E. Martenies, Chad Milando, **Stuart Batterman,** "Asthma-related health benefits of reducing SO2 exposures in Detroit, MI," Presented at the 21st Annual Environmental Health Sciences Symposium, School of Public Health, Ann Arbor, MI, Jan. 22, 2016.

221.**Stuart Batterman**, Sergei Chernyak, Feng-Chiao Su, "Measurement and Distribution of Organic Compounds in Plasma, Whole Blood and Dried Blood Spots," Presented at the SETAC Europe 26th Annual Meeting, Nantes, France, 22-26 May 2016.

222.**Stuart Batterman**, Veronica Berrocal, Owais Gilani, Chad Milando, Sarav Arunachalam (University of North Carolina), Max Zhang, "Enhancing Models and Measurements of Traffic-related Air Pollutants for Health Studies using Bayesian Data Fusion Models," Poster presented at the Health Effects Institute Annual Research Conference, Denver, CO, May 1-3, 2016.

223.Joanna Bastos, Pedro Marques, **Stuart Batterman**, Fausto Freire, "Life-Cycle Assessment of Urban Transportation Modes," Mechanical Engineering Confernce, CEM2016, Porto, Portugal, June 1-3, 2016.

224.Chad W. Milando, Sheena E. Martenies, **Stuart A. Batterman**, "Emissions scenario optimization through a flexible dispersion modeling framework", presented at the 109th Annual Conference of the Air & Waste Management Assoc., June 20–23, 2016, New Orleans, LA.

225.Sheena E. Martenies, Chad W. Milando, **Stuart A. Batterman**, Urban scale pollutant mitigation strategies to reduce the burden of disease: An application in Detroit, MI", presented at the 109th Annual Conference of the Air & Waste Management Assoc., June 20–23, 2016, New Orleans, LA.

226.TC Lewis, TG Robins, **SA Batterman**, B Mukherjee, GB Mentz, EA Parker, Community Action Against Asthma (CAAA) Steering Committee Daily. "1-hour peak levels of sulfur dioxide are associated with increased respiratory symptoms in Detroit children with asthma," presented at the American Thoracic Society Annual Meeting, San Francisco, CA. May 13-18, 2016.

227. Lewis TC, Metitiri EE, Winer IH, Comstock AT, Goldsmith AM, Ren X, Mentz GB, Robins TG, **Batterman SA**, Mukherjee B, Hershenson MB, Community Action Against Asthma Steering Committee. "Nasal aspirate CXCL10, CXCL8 and IFN-λ correlate with symptoms and lung function in inner-city asthmatic children with respiratory viral infections." Presented at the American Thoracic Society Annual Meeting, San Francisco, CA. May 13-18, 2016.

228.Lewis TC, Metitiri EE, Winer IH, Comstock AT, Goldsmith AM, Ren X, Mentz GB, Robins TG, **Batterman SA**, Mukherjee B, Hershenson MB and the Community Action Against Asthma Steering Committee. "In inner-city children with asthma infected with rhinovirus, viral load correlates with nasal aspirate cytokine expression but not respiratory symptoms." Presented at the American Thoracic Society Annual Meeting, San Francisco, CA. May 13-18, 2016.

229.T.C. Lewis, E.A. Parker, T.G. Robins, **S.A. Batterman**, B. Mukherjee, G.B. Mentz, X. Ren, C. Godwin, B.A. Israel. Bedroom HEPA Air Filters Can Improve Respiratory Health of Children With Asthma In Detroit." Presented at the American Thoracic Society Annual Meeting, San Francisco, CA. May 13-18, 2016.

230.Jaclyn M. Goodrich, Poovendhree Reddy, Rajen N. Naidoo, Kareshma Ramcharan, **Stuart Batterman**, Dana C. Dolinoy, "DNA Methylation and the in utero environment in a mother-child cohort from Durban, South Africa," presented at the 28th annual International Society for Environmental Epidemiology conference, Rome, Italy, Sept 1-4, 2016.

231.R. Naidoo, G.B. Mentz, T.G. Robins, **S. Batterman**, Daily variations in respiratory symptoms among school children associated with air pollution fluctuations," presented at the 28th annual International Society for Environmental Epidemiology conference, Rome, Italy, Sept 1-4, 2016.

232.**Stuart A. Batterman**, Geoffrey Thun, Geng-Chiao Su, Andrew Wald, Flloyd Watkins, Lexuan Zhong, Christopher Godwin, Jean Wineman, Cheryl Somers, "Indoor Environment in Schools: Comparing Conventional and High Performance Schools, paper presented at Indoor Air 2016, Ghent, Belgium, July 3-7, 2016.

233.Andrew Wald, Geoffrey Thun, **Stuart A. Batterman**, Cheryl Somers, Jean Wineman. "Evaluating Health Impacts on Public School Design: Indoor Environment Quality Comparing Conventional and High Performance Schools, presented at the ACSA/ASPPH Fall Conference on Building for Health & Well-Being, September 22-24, 2016, Honolulu, HI.

234.Regina Royan, Zsuzsanna Szabo, Kathryn Sutcliffe, Brian Stamm, Christopher Godwin, Eden V. Wells, **Stuart Batterman**, "Self-Regulation in the Age of Urban Revitalization: Evaluating Lead Dust Fallout From Residential Demolitions in Detroit, MI," presented at the Annual Meeting of the American Public Health Association, Oct. 29-Nov. 2, 2016, Denver, CO.

235.Sheena Martenies, Angela G. Reyes, **Stuart Batterman**, "Health and equity impacts of alternative air quality management strategies: A quantitative heath impact assessment for Detroit, Michigan," presented at the Annual Meeting of the American Public Health Association, Oct. 29-Nov. 2, 2016, Denver, CO.

236.Feng-Chiao Su, Andrew Wald, Floyd Watkins, Christopher Godwin, Geoffrey Thun, Jean Wineman, Cheryl Somers, **Stuart Batterman**. "An Assessment of Correlations between Teachers' Perceptions, Student Learning and

Indoor Environmental Quality in Schools in the U.S.", presented at the Annual Meeting of the American Public Health Association, Oct. 29-Nov. 2, 2016, Denver, CO.

237. Schulz, A.J, Batterman, S., Reyes, A.G., Williams, G., Rice, K.L. "Creating a Public Health Action Plan to Translate Research to Action and Policy Change." presented at the Annual Meeting of the American Public Health Association, Oct. 29-Nov. 2, 2016, Denver, CO.
238. Joana Bastos, Pedro Marques, **Stuart A. Batterman**, Fausto Freire, "Comparative Life-Cycle Assessment of Urban Road Transport: Application to Commuting in Portugal," presented at the University of Michigan Transporation Research Institute Transportation Safety Research Symposium, October 6, 2016, Ann Arbor, MI.
239. Stuart Batterman; Amy Schulz; Kristina Rice, Community Action to Promote Healthy Environments (CAPHE): Mobile Source Controls, Community Meeting, Detroit, MI., Jan 24, 2017.
240. Joana Bastos, Pedro Marques, **Stuart A. Batterman**, Fausto Freire, "Comparative Life-Cycle Assessment of Urban Road Transport: Application to Commuting in Portugal," presented at the National Council for Science and the Environment National Conference and Global Forum on Science, Policy and the Environment, January 24-26, 2017, Washington, DC.
    This poster was selected as one of the top four student posters.
241. **S. Batterman**, Gordie Howe International Bridge: Air Monitoring & Health Impact Assessment, Community Meeting, January 25, 2017, Detroit, MI.
242. Zhong, L, J. J. Brancho, **S. Batterman**, B. M. Bartlett, C. Godwin. "Evaluation of Visible Light Responsive Photocatalytic Oxidation (PCO) Building Materials for Indoor Volatile Organic Compounds (VOCs) Removal," presented at the 20th annual meeting of the Indoor Air Quality Association, Las Vegas, NV, Jan. 30 – Feb. 1, 2017.
243. Zoey Laskaris, Stuart Batterman, Nil Basu, Julius Fobil, Thomas Robins, Electronic and electrical equipment waste in Ghana, EPID Student Presentations, School of Public Health, Ann Arbor, MI. March, 2017.
244. Lexuan Zhong, **Stuart Batterman**, "Occupational exposures to VOCs in nail salons in Michigan," Poster presented at the Education and Research Center (ERC) Regional Research Symposium, University of Michigan, March 17, 2017, Ann Arbor, MI.
    This poster was awarded received the "People's Choice."
245. Sheena E. Martenies, **Stuart A. Batterman**, "Assessing the health impacts and health burden inequality of ambient air pollution in Detroit, MI," Poster presented at the 22nd Annual Environmental Health Sciences Research Symposium. University of Michigan, March 24, 2017, Ann Arbor, MI.
    This poster was awarded a first prize including a monetary award.
246. **Stuart Batterman**, Veronica Berrocal, Owais Gilani, Chad Milando, Sarav Arunachalam (University of North Carolina), Max Zhang, "Enhancing Models and Measurements of Traffic-related Air Pollutants for Health Studies using Dispersion and Bayesian Fusion Models," Poster presented at the Health Effects Institute Annual Research Conference, Alexandria, VA, April 30 – May 2, 2016.
247. **Stuart Batterman**, Guy Williams, "Development of an Air Quality Action Plan for Detroit, Michigan," Presented at the Citizen Science Association Meeting, Minneapolis, MN, May 17-20, 2017.
248. Joana Bastos, Chad Milando, Fausto Freire, **Stuart Batterman**, "Exploring intra-urban variability of intake fractions for $PM_{2.5}$: an application to the life-cycle assessment of road transport in Lisbon, Portugal," Paper presented at the International Society for Industrial Ecology (ISIE) and the 25th annual conference of the International Symposium on Sustainable Systems and Technology (ISSST), Chicago, Illinois, USA, June 25-29, 2017.
249. Julius N. Fobil, Niladri Basu, **Stuart Batterman,** Thomas G. Robins, "Michigan-West Africa CHARTER II in GEOHealth: Climate variables, ambient air quality and human exposure to environmental pollutants, Submitted to Climate Services Conference, South Africa, 2017.
250. Schulz, A.J., **Batterman**, S., Rice, K., Heymach, W., Israel, B.A., Lewis, T., Markarian, E., Martenies, S., Reyes, A.G., Ward, M., Williams, G.., Community-Academic Partnership to Develop and Implement a Public Health Action Plan to Reduce Air Pollution and Promote Health Equity in Detroit." Presented at the the American Public Health Association Annual Meeting, Atlanta, GA, Nov. 8 – 8, 2017.
251. Carina Gronlund, Alyssa Yang, Marie O'Neill, Hien Q. Le, **Stuart Batterman,** Robert Wahl, Lorri Cameron, Leah Comment , "Association Between High Temperature and Pre-term Birth in a High-Risk City," Presented at the American Public Health Association Annual Meeting, Atlanta, GA, Nov. 8 – 8, 2017.
252. **Stuart Batterman**, Simone Sagovec, "Clean Air Action Plan for Detroit," Invited presentation at the Fall joint Environmental Conference, State Bar of Michigan Environmental Law Section and East Michigan & West Michigan Chapters of the Air & Waste Management Association, Nov. 8, 2017, West Lansing, MI.

253. Daniel Katz, **Stuart Batterman**, "Predicting ragweed pollen exposure," Poster presented at Translational Science, Assoc. for Clinical and Translational Science, Washington, DC. April 19-21, 2018
254. Stuart Batterman, "Can school buildings make kids healthy and smart? New findings by EPA's research grantees." Green Schools Conference and Expo, May 3-4, 2018, Denver, CO.
255. Kristina Rice, Jimenez, V., Heymach, W., Reyes, A.G., Stott, K., Stritz-Calnin, M. Ward, M., Williams, G., Schulz, A.J., Batterman, "Community Action to Promote Healthy Environments (CAPHE): Community-Academic Partnership to Develop and Implement a Public Health Action Plan to Reduce Air Pollution and Improve Community Health in Detroit," Beyond the Ivory Tower; University-Community Engagement, Detroit, MI, June 5-6, 2018.
256. Stuart Batterman, "Measuring Ventilation in IAQ Studies of Schools: Challenges and Solutions," Presentation and Workshop, Presented at Indoor Air 2018, June 22-27, 2018, Philadelphia, PA.
257. Carina J. Gronlund, Alyssa J. Yang , Kathryn C. Conlon, Marie S. O'Neill, Sung K. Park, Hien Q. Le, **Stuart A. Batterman**, Robert L. Wahl, Lorraine Cameron, "High Temperature Associations with Preterm Birth and Mediation by Air Pollutants in Detroit, Michigan, 1991-2001." Presented at the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
258. **Stuart Batterman**, Cheryl Somers, Geoffrey Thun, Nan Yan, "Environmental Quality, Health and Learning in Conventional and High Performance School Buildings," Presented at the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
259. Nan Yan, **Stuart Batterman**, Cheryl Somers, Christopher Godwin, Nicole Mitchell, "Environmental Interventions in Primary Schools and Its Impacts on Indoor Air Quality and Students Health," submitted to the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
260. **Stuart Batterman**, Sheryl Magzamen, Meredith McCormack, "Healthy Schools: Understanding Indoor Environmental Quality, Occupant Health, and Academic Performance," Symposium to be presented at the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
261. Julius N. Fobil, Niladri Basu, **Stuart Batterman**, Thomas G. Robins, "The West African-Michigan CHARTER II for GEOHealth," submitted to the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
262. Paola Filigrana, Chad Milando, **Stuart Batterman**, Sara D. Adar, "The Influence of Fine-Scale Spatiotemporal Variation of Traffic on Exposures to Traffic-Generated PM2.5, NOx and Black Carbon in Communities Located Near Highways, submitted to the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
263. Paola A. Filigrana, Chad Milando, **Stuart Batterman**, Adam Szpiro, Sara D. Adar.Paola Filigrana, Chad Milando, Stuart Batterman, Sara D. Adar, "Near-Road Exposures to Traffic-Generated PM2.5, NOx and Black Carbon and the Risk of Daily Mortality: A Case-Crossover Study, Poster presented at the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
264. Katz, Daniel S, **Stuart Batterman**, "Measurement Error in Epidemiological Studies of Allergenic Pollen Due to Heterogeneity in Flowering Phenology," presented at the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
265. Laskaris, Zoey, Chad Milando, Marie S. O'Neill, Julius Fobil, Nil Basu, Thomas Robins, **Stuart Batterman**, Can time-lapse photography improve risk characterization in informal labor sectors?, Poster presented the ISES-ISEE 2018 Joint Annual Meeting in Ottawa, Canada, 26-30 August 2018.
266. "**Stuart Batterman**, Meredith McCormack, Lilly Wong, "Can school buildings make kids healthy and smart? Innovative explorations and findings by EPA's school health research grantees," Education Session presented at Green Build International Conference and Expo, Chicago, IL, Nov. 14-17, 2018.
267. Stuart Batterman, "Exposed: Pathways from Normal to Extreme in Exposure Science," Environmental Research Seminar, University of Michigan, Ann Arbor, MI, April 2, 2019
268. Stuart Batterman, Environmental Quality, Health and Learning in Conventional and High Performance School Buildings, presented at The Center for Green Schools 2019 School District Sustainability Leader's Summit, Minneapolis, MN April 10-11, 2019.
269. Barabara Israel, Amy J. Schulz, Stuart Batterman, Kristina Rice, Angela G. Reyes, Guy Williams, "Development and Implementation of a Public Health Action Plan to Inform Policies to Promote Air Quality, Health and Well-Being in an Urban Community", World Conference on Health Promotion, IUHPE, Rotorua, Aotearoa, New Zealand, April 8, 2019
270. Joana Bastos, Rita Garcia, **Stuart A. Batterman**, Fausto Freire, Environmental And Health Benefits Of A Bicycle Sharing System: A Comprehensive Approach, paper presented at the Energy for Sustainability International Conference 2019: Designing a Sustainable Future. Turin, July 24-26, 2019.

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29. **S. Batterman**, “The Environmental Protection Agency: structuring motivation in a green bureaucracy: the conflict between regulatory style and cultural identity, R. McMahon (book review), *Choice*, Dec. 2006.
30. **S. Batterman**, “Risk and reliability analysis: a handbook for civil and environmental engineers, P. Vijay, SK Jain and A Tyagi, (book review), *Choice*, May, 2008.
31. **S. Batterman**, “Global environmental outlook: environment for development, United Nations Environment Program, (book review), *Choice*, 2008 (in press).
32. **S. Batterman**, “The Engineering Guide to LEED-new construction: sustainable construction for engineers. L. Haselbach, McGraw-Hill, (book review), *Choice*, 2008 (in press).
33. **S. Batterman**, “Catalogue of risks: Natural, technical, social and health risks.” Dirk Proske. Springer, London, 2008. (book review), *Choice*, March, 2009.
34. **S. Batterman**, “Handbook of Performability Engineering, Krishna B. Misra, ed., Springer-Verlag, London (book review), *Choice*, August, 2009.
35. **S. Batterman**, “Understanding Green Building Guidelines,” Traci Rose Rider, W.W. Norton & Co., New York (book review), *Choice*, Dec., 2009.
36. **S. Batterman**, “Air Pollution Measurement, Modeling, and Mitigation, A. Tiwary, J. Colls, Routledge, 2010, (book review), *Choice*, January, 2010.
37. **S. Batterman**, “Risk in Technological Systems,” Grimvall G., ed., Springer-Verlag, London. 2010 (book review), *Choice*, April, 2010.
38. **S. Batterman**, "Understanding Environmental Pollution, 3rd Ed.," Marquita Hill, Cambridge University Press, 2010. (book review) *Choice*, Nov. 2010

39. **S. Batterman**, “Air Pollution - Health and Environmental Impacts,” Gurjar BR, Molina LT, Ojha CSP, eds. CRC Press, Boca Raton, FL, 2010 (book review), *Choice*, Jan, 2011.
40. **S. Batterman**, "Patty's industrial hygiene: v.1: Hazard recognition; v.2: Evaluation and control; v.3: Physical and biological agents; v.4: Program management and specialty areas of practice, ed. by Vernon E. Rose and Barbara Cohrssen. 4 volumes. 2011 (book review), *Choice*, June, 2011.
41. **S. Batterman**, "Understanding green building materials" TR Rider, S Glass, J McNaughton, WW Norton Press, 189 p. 2011 (book review), *Choice*, Nov., 2011.
42. **S. Batterman**, "Stakeholders and scientists: achieving implementable solutions to energy and environmental issues," ed. by Joanna Burger. Springer, 2011. 453p, 189 p. 2011 (book review), *Choice*, Jan., 2012.
43. **S. Batterman**, "Introduction to environmental engineering." S Franzle, B Markert, and S Wunschmann. Wiley VCH. 453p, 2012 (book review), *Choice*, May, 2012.
44. **S. Batterman**, “Industrial disasters, toxic waste, and community impacts: health effects and environmental justice struggles around the globe,” FO Adeola, Lexington Books, 2012, 291p (book review) *Choice*, June 2013.
45. **S. Batterman**, “Air pollution prevention and control: bioreactors and bioenergy, ed. by Christian Kennes and Marcia C. Veiga. Wileym London, 2013, 549 (book review) *Choice*, Sept. 2013.
46. **S. Batterman**, "The Human and Environmental Impacts of Fracking", Madeline Finkel, Prager Press, 2015, 219 p. (book review), *Choice*, Sept. 2015.

Other

47. **S. Batterman**, “Air Quality Measures for Epidemiological Investigations,” M.S. Thesis, Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA, 1981.
48. **S. Batterman**, “Prediction and Apportionment of Ambient Air Pollutants,” Ph.D. Thesis, Civil Engineering, Massachusetts Institute of Technology, Cambridge MA, 1986.
49. **S. Batterman**, Contributor, <u>The Environmental Science Encyclopedia,</u> Cunningham, W.P., T. H. Cooper, E. Gorham, M.T. Hepworth, A.A. Marcus, eds., Gale Research Pub., 1994.
50. **S. Batterman**, “Review of the Metamora Landfill Superfund Site Cleanup,” Technical Assistance Grant Report, also published in citizen group newsletter, September 1, 1994.
51. **S. Batterman**, “Review of the Metamora Landfill National Priority List Site,” Metamora Technical Advisory Committee, Lapeer MI, April 1994. Published in citizen newsletter June 1995.
52. **S. Batterman**, A. Duncan, E. Spiegel, et al., <u>Environmental Management at the University of Michigan: A Report from the Greening the Maize and Blue Advisory Committee</u>, University of Michigan, Ann Arbor, MI, May, 1996.
53. **S. Batterman**, “An Update on the ROD Changes to Metamora Landfill National Superfund Site”, Metamora Concerned Citizens Newsletter, Oct. 1996.
54. **S. Batterman**, “Metamora Landfill Community Update”, Technical Assistance Grant (TAG) Advisory Committee, Winter 1997.
55. **S. Batterman**, “Metamora Landfill Community Update and Newsletter”, Technical Assistance Grant (TAG) Advisory Committee, January 7, 1999.
56. **S. Batterman**, “Metamora Landfill Community Update and Newsletter”, Technical Assistance Grant (TAG) Advisory Committee, February 25, 1999.
57. **S. Batterman**, E. Barnett, C. Harms, P. Kalliokoski, T. Metts, “Indoor Air Quality Study for Quick Reliable Printing,” Precision Air, Inc., April 25, 2001, 56 p.
58. J. Nriagu, **S. Batterman**, J. Gannon, “History Of Environmental Health Sciences at The University Of Michigan,” on UM SPH Web site: <u>http://www.sph.umich.edu/ehs/history.html</u>, Sept. 2001.
59. **S. Batterman**, “EHS Field Experience Handbook: A Guide for MPH Students,” Department of Environmental Health Sciences, University of Michigan, Ann Arbor, MI, October, 2001, 29 p.
60. A. J. Ervin, **S. Batterman**, “Effects of Air Ionization on Indoor Air Pollutants,” Poster presented at the Undergraduate Research Opportunity Program (UROP) Spring Research Symposium, University of Michigan, Ann Arbor, MI, April 10, 2002.

61. U.R. Okwumabua, **S. Batterman**, “High Pollution Days in Durban, South Africa: Meteorological Factors,” Poster presented at the Undergraduate Research Opportunity Program Spring Research Symposium, University of Michigan, Ann Arbor, MI, April 10, 2002.
62. **S. Batterman**, A. Dalvie, “External Examination – University of Botswana, Gabarone, Botwana, Nov. 6, 2008. Submitted to the Deputy Vice Chancellor of Academic Affairs, University of Botswana. 17 p.
63. **S. Batterman**, Mary Anne Carroll, Knute J Nadelhoffer, “Internal Review Committee Report on the Graham Environmental Sustainability Institute,” submitted to the Provost, University of Michigan, Ann Arbor, March 28, 2009.
64. **S. Batterman**, “Report on sulfur dioxide (SO_2) exposures from a large sulfur fire at a sulfur forming and shipping facility,” Submitted to Ackroyd LLP, 15th floor, First Edmonton Place, 10665 Jasper Avenue, Edmonton, Alberta, March 29, 2009.
65. US EPA, **S. Batterman** et al. "Fact sheet: Science in Action: Health Effects of Roadway Pollution: Joint Research Project by the U.S. Environmental Protection Agency and University of Michigan," http://www.epa.gov/nerl/documents/NearRoadwayTechnical_external_fact_sheet_071910.pdf, 2011.
66. **S. Batterman**, "Health Effects of Hydrogen Sulfide Exposures: A Review of the Evidence Pertaining to Low Level Exposures", Sierra Club, Washington, DC. Aug. 2012, 56 p.

Invited Lectures and Presentations

1. **S. Batterman**, "Uncertainty of Targeted Acid Rain Control Strategies," Technical Research Center of Finland, Helsinki, Finland, Jan. 8, 1990
2. **S. Batterman**, "Hazardous Substance Regulation," and "Hazardous Substance Analysis: Volatile Organic Compounds," lectures prepared for course Hazardous Substance Sampling and Monitoring, Center for Occupational Health and Safety Engineering, University of Michigan, Ann Arbor MI, March 18-20, 1991.
3. **S. Batterman**, "Hazardous Substance Regulations," Presented to class EIH 503, Principles of Environmental Health, University of Michigan, Ann Arbor MI, Jan. 22, 1992.
4. **S. Batterman**, "Acid Rain Update," lecture presented at NSF Teacher Training Project, School of Education, University of Michigan, Ann Arbor MI, Feb. 3, 1992.
5. **S. Batterman**, "Indoor Air Quality", presented to class EIH-531 Environmental Chemistry, University of Michigan, Ann Arbor MI, Dec. 2, 1992.
6. **S. Batterman**, "Decision Making in Hazardous Waste Siting," Invited lecture presented to ChE 195, Introduction to Engineering Analysis, College of Engineering, University of Michigan, Ann Arbor MI, March 17, 1993.
7. **S. Batterman**, "Hazardous Substances Academic Training Program," Presentation to the Advisory Committee, University of Michigan Center for Occupational Health and Safety Engineering, Ann Arbor MI, June 23, 1993.
8. **S. Batterman**, "Pollution Sources in HVAC Systems: Phase 2. Identification and Quantification of Sources," Presentation to the National Institute for Occupational Safety and Health, University of Michigan, Ann Arbor MI, June 24, 1993.
9. **S. Batterman**, "Diffusion Processes in Soils: Measurements and Models," Lawrence Livermore National Laboratory Environmental Restoration Group, Livermore CA, July 2, 1992.
10. **S. Batterman**, H. Burge, E. Albert et al. "Pollution Sources in HVAC Systems," Presentation to the U.S. Environmental Protection Agency, Air and Energy Engineering Laboratory, Research Triangle Park NC, July 13, 1993.
11. **S. Batterman**, "Environmental Accounting" and "Life Cycle Analysis," Two invited lectures presented to English for Business and Management Studies, University of Michigan, Ann Arbor MI, July 19, 1993.
12. **S. Batterman**, P. Milne, M. Dojka, "Diffusion Measurements Update," Presentation to U.S. Department of Energy, Ann Arbor, Oct. 21, 1993.
13. **S. Batterman**, "Deficiencies in Cleanup Plans for Metamora Landfill National Priorities List Site," Technical Advisory Committee, Congressman Kildee's Office, Flint MI, Jan. 3, 1994.
14. **S. Batterman**, "Curriculum of the Hazardous Substances Academic Training Program at the University of Michigan," Presentation to the National Institute for Occupational Safety and Health Annual Meeting of the Directors of the Hazardous Substances Academic Training Program, Stevenson WA, Feb. 15-16, 1994.

15. **S. Batterman**, "Introduction to Environmental Impact Assessment," Invited lecture presented to Course SNRE-370, Introduction to Urban and Environmental Planning, School of Natural Resources and Environment (also to course ARCH-423, Introduction to Architecture and Urban Planning), University of Michigan, Ann Arbor MI, March 24, 1994.
16. **S. Batterman**, "The Proposed Flint Waste-to-Energy Cogeneration Facility: Potential Environmental Impacts," Invited lecture presented to Course COMM-500, Natural Resources/Communications and the Scripts Fellowship Program, University of Michigan, Ann Arbor MI, Sept. 28, 1994.
17. **S. Batterman**, "The Regulatory Process," Invited Lecture to Course COMM-500, Natural Resources/Communications and the Scripts Fellowship Program, University of Michigan, Ann Arbor MI, Oct. 5, 1994.
18. **S. Batterman**, "Environmental Impact Assessment," Invited lecture presented to Course SNRE-370, Introduction to Urban and Environmental Planning, School of Natural Resources and Environment (also to course ARCH-423, Introduction to Architecture and Urban Planning), University of Michigan, Ann Arbor MI, Nov. 3, 1994.
19. **S. Batterman**, "Needs Assessment for the Hazardous Substances Academic Training Program," Presentation to the Directors of the NIOSH HSAT Programs, Redondo Beach CA, Feb. 13, 1995.
20. **S. Batterman**, "Use of an Automated GC-MS Chamber Testing System," Presentation to the Forest Products Laboratory, Madison, WI, August 23-4, 1995.
21. C. Gelman, O. Osak, **S. Batterman**, "New Filters for High Volume Air Samplers," Presentation to US Environmental Protection Agency, Research Triangle Park, NC, Sept. 18, 1995.
22. **S. Batterman**, "Review of Cleanup Plans for Metamora Landfill National Priorities List Site," Technical Advisory Committee, Congressman Kildee's Office, Pontiac, MI, Sept. 28, 1995.
23. **S. Batterman**, "Changes in the Record of Decision for the Metamora Landfill National Priorities List Site," Technical Advisory Committee, Congressman Kildee's Office, Pontiac, MI, April 16, 1996.
24. **S. Batterman**, "Comments on the Metamora Landfill Superfund Site ROD Recommendation," US EPA/Michigan DEQ Public Hearing, Metamora, MI, April 23, 1996.
25. **S. Batterman**, "Evaluation of the Risk Analysis for the Texas Industries (TXI) Facility in Midlothian, Texas," Cedar Hill, TX, May 28, 1996.
26. **S. Batterman**, "Environmental Impact and Risk Assessment," Two invited lectures presented to English for Business and Management Studies, University of Michigan, Ann Arbor MI, July 17, 1996.
27. **S. Batterman**, "An Overview of Air Pollution Related Research," Invited lecture to Building Technology Group, Technical Research Centre of Finland, Espoo, Finland, Aug. 22, 1996.
28. **S. Batterman**, "Update on the Metamora Landfill National Priorities List Site," Technical Advisory Committee, Lapeer, MI, February 13, 1997.
29. **S. Batterman**, "The Metamora Landfill National Priorities List Site Remediation Program," Technical Advisory Committee and Public Meeting, Metamora, MI, April 23, 1997.
30. **S. Batterman**, "Risk Assessment of Waste Combustion," Invited lectures presented to English for Business and Management Studies, University of Michigan, Ann Arbor MI, July 24, 1997.
31. **S. Batterman**, "Effects of Technology on Biomedical/Environmental Issues," Invited lecture to the University of Michigan Undergraduate Research Opportunities Program, Dec. 3, 1997.
32. **S. Batterman**, "Estimating Routine and Extreme Exposures in Environmental and Occupational Health," Dept. of Epidemiology and Preventative Medicine, University of California, Davis, CA, Feb. 11, 1998.
33. **S. Batterman**, "The Metamora Landfill National Priorities List Site Remediation Program," Technical Advisory Committee and Public Meeting, Lapeer, MI, April 27, 1998.
34. **S. Batterman**, "Extreme Environmental Exposures: A Large Sulfur Fire in South Africa," Environmental Health Seminar, University of Michigan, Ann Arbor, MI, Sept. 25, 1998.
35. **S. Batterman**, "Technical Analysis in Environmental Justice Determinations," School of Law, Wayne State University, Detroit, MI, Sept. 28, 1998.
36. **S. Batterman**, "The Metamora Landfill National Priorities List Site Remediation Program," Technical Advisory Committee and Public Meeting, Lapeer, MI, Jan.7, 1999.

37. **S. Batterman**, "The Metamora Landfill National Priorities List Site Remediation Program," Technical Advisory Committee and Public Meeting, Lapeer, MI, Feb. 25, 1999.
38. **S. Batterman**, C. Bailey, "Public Health and Risk Assessment," Invited lecture to the National Student Environmental Justice Conference, Ann Arbor, MI, March 26-28, 1999.
39. **S. Batterman**, "Update and History of the Metamora Landfill National Priorities List Site," Technical Advisory Committee, Metamora, MI, April 7, 1999.
40. **S. Batterman**, "Health and Environmental Impacts of a Large Sulfur Fire," Invited lectures presented to English for Business and Management Studies, University of Michigan, Ann Arbor MI, July 29, 1999.
41. **S. Batterman**, "Trends and Practices in IAQ Management," presented to the Facilities Planning and Design Department, University of Michigan, Sept. 1, 1999.
42. **S. Batterman**, "Air Toxics and Toxicology," presented at Michigan Air Toxics Strategy Roundtable, Detroit, MI, Nov. 6, 1999.
43. **S. Batterman**, "Environmental Health Issues," presented to the Undergraduate Research Opportunities Program, University of Michigan, Nov. 10, 1999.
44. **S. Batterman**, "Environmental Management for a Large Sulfur Fire," invited lectures presented to English for Business and Management Studies, University of Michigan, Ann Arbor MI, July 20, 2000.
45. **S. Batterman**, "Health Implications of St. Lawrence Cement Facility," invited lecture and discussion presented to the St. Lawrence Cement/Community Forum, Hudson, NY, Sept. 13, 2000.
46. **S. Batterman**, "Risk Assessment and Children," invited lecture presented in course "Risk Communication," School of Natural Resources and the Environment, University of Michigan, Ann Arbor, MI, Jan. 22, 2001.
47. **S. Batterman**, "The Pentech-University of Michigan Tertiary Education Linkage Program in Faculty, Curriculum and Research Development Related to Cleaner Production Technologies and Advanced and Smart Materials, presented at the Peninsula Technikon, Bellville, South Africa, separate presentations to the faculty of Chemical Engineering and Mechanical Engineering, March 2, 2001.
48. **S. Batterman**, E. Barnett, C. Harms, "Results of Indoor Air Quality Study at Quick Reliable Printing," presented to workers and management of QRP Inc. Midland, April 24, 2001.
49. **S. Batterman**, "Research and Practice in Environmental Health, presented in the Introductory Environmental Health Sciences Seminar," University of Michigan, Oct. 5, 2001.
50. **S. Batterman** (with T. Robins), "Settlers Primary School Health Study: Interim Report," Nelson R. Mandela School of Medicine, University of Natal, Durban, South African, Feb. 28, 2002.
51. **S. Batterman**, Rappatuer on paper "Nonpoint Source Pollution: Air and Land Dimensions" by T. Gladwin et al., presented at The Great Lakes: Our Challenging Future, University of Michigan Symposium, Nov. 5-6, 2002.
52. **S. Batterman** (with T. Robins) "Settlers Primary School Health Study: Draft Final Report," Nelson R. Mandela School of Medicine, University of Natal, Durban, South African, Nov. 21, 2002.
53. **S. Batterman**, "Air pollution and environmental justice," 2 hr lecture presented to HBHE class Environmental Education (G. Gee), University of Michigan, March 13, 2002.
54. **S. Batterman**, D. Giwahla, O. Franks, "The University Michigan – Peninsula Technikon Tertiary Linkage Project (TELP) – Case Study," US AID TELP/EDDI Annual Conference, Washington, DC, March 6-9, 2003.
55. **S. Batterman**, "The South Durban Health Study," presented at "Listening to the people – A community environmental health gathering," John Dunn Hall, Gouritz Place, Wentworth, South Africa, GroundWork and South Durban Community Environmental Alliance (SDCEA), February 22, 2004.
56. **S. Batterman**, "Environmental Health Perspectives on Asthma – School of Public Health Orientation, School of Public Health, Ann Arbor, MI, Sept. 2, 2004.
57. **S. Batterman**, "Environmental Health Perspectives on Asthma – School of Public Health Orientation, School of Public Health, Ann Arbor, MI, Sept. 1, 2005.
58. **S. Batterman**, "The Indoor Environmental at Schools: Characterization and Assessment of a Public Health Issue," presented at the Seminar on Indoor Air Quality and Public Health in Schools, Centro de Saude Ambiental e Occupacional, Insituto Nacional de Saude, Porto, Portugal, Dec. 7, 2005.

59. S. Charles, **S. Batterman,** "Quantification of 2,5-dimethylfuran in Environmental Tobacco Smoke (Quantifying and Reducing Exposures to Environmental Tobacco Smoke)," presented to the 2006 University of Michigan Tobacco Research Network Workshop, School of Public Health, University of Michigan, Ann Arbor, May 9, 2006.
60. **S. Batterman**, "Assessment of Traffic Related Air Pollutants," Faculty of Science and Technology, University of Coimbra, Coimbra, Portugal, Nov. 29, 2006.
61. **S. Batterman**, "Strategies and Tools for Sustainable Development and Environmental Management," Faculty of Science and Technology, University of Coimbra, Coimbra, Portugal, Feb. 26, 2007.
62. **S. Batterman**, "Situation analysis and options for health care waste management in Mozambique. Ministry of Health, Maputo, Mozambique. June 6, 2007.
63. **S. Batterman**, "Case studies in exposure and risk assessment: Applications from A (Ais for ADME and Africa) to Z (Z is for z-score and "xenobiotic")". Presented in course EHS 688: Topics in Environmental Health, School of Public Health, University of Michigan. Oct. 8, 2008.
64. **S. Batterman**, "Public health and air quality in urban environments". Presented in course Civil Engineering 990 "Sustainable urban environments". Nov. 11, 2008.
65. **S. Batterman**, "Highways and health." Presented to the University Chapter of the American Society of Civil Engineers, Ann Arbor, Nov. 21, 2008.
66. **S. Batterman**, "Comments on Estimating Benefits of Reducing Hazardous Air Pollutants Workshop, US Environmental Protection Agency, Washington, DC., April 30 and May 1, 2009.
67. **S. Batterman**, "Vignettes in air pollution and waste management: Vehicle emissions, medical waste, and emerging pollutants," EWRE Research Seminar, Civil Engineering, University of Michigan, Ann Arbor, MI, March 10, 2010.
68. **S. Batterman**, "Assessment and risks of PBDEs," Presented in class: EHS 508 "Risk Assessment," University of Michigan, Ann Arbor, MI, March 25, 2010.
69. **S. Batterman**, "Climate Change and Public Health: The issues, research possibilities and the need for developing postgraduate training initiatives," Environmental and Occupational Health, University of Kwa-Zulu Natal, Durban, South Africa, April 30, 2010.
70. **S. Batterman**, "Atmospheric Toxics Webinar Series (Sources of Brominated Flame Retardants)", Great Lakes Commission. Oct. 26, 2010. Available at http://www.glc.org/glad/meetings/webinar/.
71. **S. Batterman**, "Public health and air quality in urban environments". Presented in course ENVIRON 407 (Program in the Environment) "Sustainable Cities". March 29, 2011.
72. **S. Batterman,** "High Resolution Spatial and Temporal Mapping of Air Pollution in Detroit", Detroit Sustainability Indicators Integrated Assessment Workshop, Graham Environmental Sustainability Institute/Data Driven Detroit, Detroit, MI, May 23, 2011
73. **S. Batterman,** "Safeguarding God's Creation: Air." St. David's Episcopal Church, Southfield, MI, Feb. 12, 2012.
74. **S. Batterman**, "Environment Health Town Hall," course entitled "Michigan Student Caucus", School of Education, University of Michigan, Oct. 23, 2012.
75. **S. Batterman** with Maria Gunnoe and Jeremy Richardson, "Impacts of coal, and health effects of power plant emissions," panel Discussion, Rackham Graduate School, University of Michigan, Oct. 25, 2012.
76. **S. Batterman**, "Health Impacts from Air Pollution," presented at the SW District Community-Environmental Meeting, Detroit Hispanic Development Center, Detroit, MI, Jan. 31, 2013.
77. **S. Batterman**, "Air quality and your child," Community Action Against Asthma Health Fair, presented at Samaritan Health Center, Detroit, MI. April 24, 2013.
78. **S. Batterman**, "Environmental quality, schools, and health," presented at the workshop "Developing Policy on Environmental Quality, Schools, and Health in Michigan," School of Natural Resources and Environment, Kresge Foundation, Ann Arbor, MI. May 10-11, 2013.
79. **S. Batterman**, "Concentrations, exposures and health impacts of traffic-related air pollutants," presented at faculty forum, Department of Civil & Environmental Engineering, University of Michigan, Ann Arbor, May 30, 2013.
80. **S. Batterman**, with Linda Birnbaum, others, Air Pollution Community Forum, First Congregational Church of Detroit, Detroit, MI, June 18, 2013.
81. **S. Batterman**, "Environmental Determinants of Healthy and Sustainable Cities", invited keynote address at the Energy for Sustainability Conference, University of Coimbra, Coimbra, Portugal, Sept. 9-11, 2013.

82. **S. Batterman**, "Energy Surprises", Energy for Sustainability Program, University of Coimbra, Coimbra, Portugal, Sept. 18, 2013.
83. **S. Batterman**, Panel discussion of film "Unacceptable Levels," Michigan Theater, October 16, 2013.
84. **S. Batterman**, Vehicle Emissions, Pollutant Exposures, and Health, Department of Civil Engineering, University of Illinois, Campaign-Urbana, IL, Oct. 2, 2014.
85. **S. Batterman**, Vehicle Emissions, Exposures, and Health, National Fuel and Emissions Laboratory, U.S. Environmental Protection Agency, Ann Arbor, MI, Oct. 8, 2014.
86. **S. Batterman**, Traffic, emissions, air quality, exposures and health, Presented to class PH-600 Cross-Disciplinary Approaches To Public Health Challenges, Feb. 10, 2015.
87. **S. Batterman**, Challenges & Successes in Exposure Science: Biomonitoring, Environmental Measurements, and Models. Dean's Seminar, College of Public Health, University of South Florida, Tampa, FL, February 17, 2015.
88. **S. Batterman**, Vehicle Emissions, Exposures, and Health. Division of Epidemiology, Human Genetics and Environmental Science, Health Science enter, The University of Texas, Houston, TX, Feb. 27, 2015.
89. **S. Batterman**, Challenges in Exposure Science: Biomonitoring, Environmental Measurements, and Models. , College of Environmental Science and Engineering, Fujian Normal University, Fuzhou, Fujian, China. April 23, 2015.
90. **S. Batterman**, Emerging Health and Safety Issues in the Petrochemical Industry: A Life Cycle Perspective. Keynote address, International Conference of Industrial Hygiene & Occupational Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan, Apr. 25~26, 2015.
91. **S. Batterman**, Wells to Wheels: Emissions, pollutant exposure and health, School of Environment, Tsinghua University, Beijing, China, April 28, 2015.
92. **S. Batterman**, Health benefits of active mobility and healthy cities, in Win-Win: Course on Healthy Cities, Polytechnique de Turin, Turin, Italy, May 24-29, 2015.
93. Regina Royan, Kathryn Suttcliffe, Zsuzsanna Szabo, **Stuart Batterman**, Eden Wells, "Lead Dust Deposition Surrounding Demolition Events in Detroit, Michigan: Preliminary Results," Presented to Detroit City Council, Feb. 2016.
94. **S. Batterman**, A. J. Reyes, S. Martenies, "Detroit-specific Asthma Research and Interventions, Detroit Asthma Summit, Detroit, May 11, 2016.
95. **S. Batterman**, "Health Impacts of Air Pollution," Commuity Action to Promote Healthy Environments (CAPHE) Air Quality (Legislative) Luncheon, Lansing, MI, May 24, 2017.
96. **S. Batterman**, "Traffic-Related Air Pollution – An Assessment for Detroit, Environmental Working Group, State of Michigan, Lansing, MI, Oct. 30, 2017.
97. **S. Batterman**, "The EQUALS Study – children in schools," Presenteda at the US EPA Healthy Schools Meeting, Philadelphia, PA. Nov. 2-23, 2017,
98. **S. Batterman**, "Transport for health and the environment (getting around in a disruptive world)," University of Coimbra, Portugal, Dec. 19, 2017.
99. **S. Batterman**, "Traffic-related air pollutants – trends, measurements, models and impacts," Environmental and Water Resources Engineering Seminar, Dept. of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI, March 30, 2018.
100. **S.Batteman**, Community Action to Promote Health Environments (CAPHE): "Working Together to Improve Detroit's Air," All day bus tour, lecture, and demonstrations to Detroit Policy Makers, April 27, 2018, Detroit, MI.
101. S**. Batterman**, "Monitoring in the 48217 ZIP code – A Public Health Perspective." Presented at the MDEQ Community Meeting on the "48217 Community Air Monitoring Project," New Mt Hermon Baptist Church, Detroit, MI ,May 3, 2018.
102. S. Batterman, Session Co-Chair, 16th International Congress on Combustion By-Products and their Health Effects, Ann Arbor, MI. July 10-13, 2019.
103. S**. Batterman**, "Monitoring in the 48217 ZIP code – A Public Health Perspective - Update" Presented at the MDEQ Community Meeting on the "48217 Community Air Monitoring Project," New Mt Hermon Baptist Church, Detroit, MI, May 21, 2019.
104. S. Batterman, "Air quality action plans and monitoring," Air Quality Forum, Eastside Resident Environmental Health Working Group, Detroit, MI, Sept. 16, 2019.

105.S. Batterman (and others); Healthy Environments and Air Quality: COVID313 Virtual Town Halls, Detroit Public TV (reached over 6800 Facebook viewers when aired). May 15, 2020. https://www.onedetroitpbs.org/covid313-virtual-townhall-healthy-environments-and-air-quality/

106.S. Batterman. Air Quality and Health. Presented at the NeuroNetwork for Emerging Therapies Mini Symposium Series: Climate Change, the Environment and Health, Oct. 15, 2020.

107.S. Batterman. Reflections on environmental research. University of Michigan's Chapter of Chi Epsilon Civil Engineering Honor Society, Oct. 22, 2020.

Full-Time Graduate Level Courses

Development and delivery of following courses:

1. CVEN-607 - Engineering Aspects of Air Pollution. Introductory course addressing air quality fundamentals, including air quality regulations; source emissions; abatement technologies; dispersion and receptor modeling; source apportionment and management; monitoring instrumentation; and contemporary air pollution issues. (Texas A&M University)
2. CVEN-681 - Graduate Seminar in Environmental Engineering. Student seminars on various research topics. (Texas A&M University)
3. EHS-572 - Environmental Impact Assessment. Comprehensive framework for evaluating and predicting environmental impacts of manmade projects including evaluative and predictive methods addressing air, water and soil quality; transport and fate of contaminants; selection, application, integration and evaluation of computer models; and risk assessment. Also cross-listed in the School of Natural Resources. (University of Michigan)
4. EHS-599 - Hazardous Wastes: Regulation, Remediation and Worker Protection. Focus on hazardous waste site assessment and cleanup, including surface water, groundwater and air investigations; remediation practices; ultimate disposal of wastes; facility siting; monitoring methods; worker and community protection. This course is also cross-listed in the College of Engineering. (University of Michigan)
5. EHS-670 - Studies in Advanced Water Resource Science and Engineering. In-depth case studies of ongoing proposals and permit applications to site or remediate hazardous waste facilities (incinerators, landfills, etc.) including evaluation of technical issues; facility siting; risk assessment; policy; risk management; regulatory aspects; and communication and public relations. In 1993, this course was also cross-listed in the School of Literature, Sciences and Arts. (University of Michigan)
6. EHS-680 - Environmental Management of Hazardous Substances. Overview of selected topics in environmental management, including risk assessment, life cycle analysis, environmental justice, and risk-based decision making. (University of Michigan)
7. Characterization of Indoor and Outdoor Pollutants and Exposure Assessment. Graduate course in air pollution, focusing on exposure assessment to indoor and outdoor air pollutants. (University of Kuopio, Department of Environmental Sciences, Oct. 28 - Nov. 1, 1996, 18 lecture-hours)
8. Indoor Air Pollutants and their Behavior. Post-graduate course addressing indoor air pollutants, including assessment, monitoring and modeling. (Technical University of Helsinki, Department of Mechanical Engineering, Dec. 9 - 13, 1996, 20 lecture-hours)
9. EHS-869 - Doctoral Student Seminar (formerly Industrial Hygiene Student Seminar.) Research and literature related to industrial hygiene, environmental health sciences, and environmental management.
10. EHS-796 - Environmental Impact Assessment Models and Applications - Modeling and quantitative assessment techniques used in the field. (University of Michigan).
11. Participation in other courses in the Environmental Health Department at the University of Michigan includes:

    EIH-501 - Toxic Exposures at Work and Home. 3 hour lectures on environmental exposure assessment. (1997, 1998, 10/1999, 1/2000)

    EIH-503 - Principles of Environmental Health. Occasional lectures.

    EIH-531 - Environmental Chemistry. Occasional lectures and laboratory demonstrations.

    EHS-585 – Introductory Environmental Health Sciences. Occasional lectures.

    EHS-507 – Principles of Exposure Assessment. Occasional lectures (2002-)

    EHS-601 – Foundations in Environmental Health Sciences. Regular lectures (2011-)

(Participation in courses in other departments, seminars and conferences is shown in Other Invited Lectures and Presentations and Service.)

12. Introduction to Environmental Impact Assessment. 6 lecture hours, including computer modeling, at KwaZulu Natal University, Durban, South Africa, Aug. 23-26, 2004.
13. EHS 510 - Responsible Conduct of Research and Scholarship. This course addresses the NIH goals of providing integrity and building awareness and understanding of established professional norms and ethical principles in all activities related to scientific research and academia. (University of Michigan).
14. EHS-510, Sustainability and Environmental Health. Graduate section of EHS-410 (described below).

Full-Time Undergraduate Level Courses

Development and delivery of following courses:

15. CVEN-302 - Computer Applications in Engineering. Numerical methods applied to engineering problems, including errors; roots of equations; systems of equations; curve fitting; regression; interpolation; integration; ordinary differential equations; and partial differential equations. (Texas A&M University)
16. CVEN-383 - Engineering Systems Analysis I. Introductory probabilistic considerations in civil engineering systems design, including models and modeling practices; systems engineering language and communication; probability concepts; inferential statistics; civil engineering systems; and decision-making models. (Texas A&M University)
17. CVEN-384 - Engineering Systems Analysis II. Applications of systems analysis techniques to engineering design, operation and maintenance issues, including modeling; numerical methods; optimization; engineering economics; and project planning and evaluation. (Texas A&M University)
18. EHS-410, Sustainability and Environmental Health. This 3-hour course introduces the key factors, drivers, and metrics that link human health and sustainability concerns with the perspective of identifying solutions that promote environmental health. Also offered as a 500-level graduate course. (University of Michigan, with Olivier Jolliet; starting winter 2017)

Continuing Education Courses

19. Air Quality Modeling, Monitoring, and Control. Advanced continuing education course for engineers and practitioners. 24 lecture hours. Peninsula Technikon, Cape Town, South Africa, July 16-18, 1997.
20. Risk Assessment and Environmental Health. Continuing education for instructors and government practitioners in environmental health management. 40 lecture hours. With J. Nriagu. University of Natal, Durban, South Africa; also Peninsula Technikon, Cape Town, South Africa, July 7-12, 1997.
21. Exposure, Hazard, and Risk Assessment. Advanced continuing education course for engineers and practitioners, including use of ALOHA and RMP*COMP computer models, 35 lecture hours. Peninsula Technikon, Cape Town, South Africa; also University of Natal, Durban, South Africa, July 19-23, 1999.
22. Review of Air Quality Control Engineering, AIHA Industrial Hygiene Refresher Course 1.5 lecture hour. University of Michigan, Ann Arbor, Aug. 17-20, 1999; March 19-24, 2000; Sept. 25-29, 2000; March 26-30, 2001; Sept. 10-14, 2001; April 8-12, 2002; Sept. 9-13, 2002; April 8-12, 2002; Sept. 9-13, 2002; Mar. 31-Apr. 4, 2003; July 28 – Aug. 1, 2003; Mar 29- Apr. 2, 2004; Sept. 19 – 23, 2005; Sept. 17-21, 2007, April 2010; Sept. 20-24, 2010; March 28-April 1, 2011; Sept. 23-27, 2013;
23. Indoor Air Quality Assessment and Management, AIHA Industrial Hygiene Refresher Course 1.5 lecture hour. University of Michigan, Ann Arbor, March 26-30, 2001; Sept. 10-14, 2001; April 8-12, 2002; Sept. 9-13, 2002; Mar. 31-Apr. 4, 2003; July 28 – Aug. 1, 2003; Mar 29- Apr. 2, 2004; Sept. 19 – 23, 2005; Sept. 17-21, 2007. April, 2010; Sept. 20-24, 2010; March 28-April 1, 2011; Sept. 23-27, 2013;
24. Workshop On Indoor Air Quality, 6 lecture hour. Indoor air quality programme for environmental health practitioners: combining theory with practice. Centre For Occupational And Environmental Health, School of Family & Public Health Medicine, Nelson R Mandela School Of Medicine, Durban, South Africa, July 9-14, 2007.
25. Review of Air Quality Control Engineering, Comprehensive Industrial Hygiene Review, 2 lecture hours. UM & Michigan Industrial Hygiene Society, Ann Arbor, MI. Sept. 26-30, 2016; Mar. 20-24, 2017, Sept. 25-29, 2017; March 12-16, 2018; Sept. 24-28, 2018, March 11-15, 2019
26. Indoor Air Quality Assessment and Management, Comprehensive Industrial Hygiene Review, 2 lecture hours. UM & Michigan Industrial Hygiene Society, Ann Arbor, MI. Sept. 26-30, 2016; Mar. 20-24, 2017; Sept. 25-29, 2017; March 12-16, 2018; Sept. 24-28, 2018, March 11-15, 2019

Educational Advising

Doctoral Dissertation Research Committees

Chair

1. Chung-Yu Peng - Identification and quantification of VOC emissions from buildings and heating, ventilating and air conditioning systems", Environmental and Industrial Heath, Sept. 1998. Associate Prof. Department of Public Health, Kaohsiung Medical University, Kaohsiung, Taiwan.
2. Mariana Luoma - "Aerosol measurements and particle deposition in HVAC systems," Ph.D., Environmental and Industrial Heath, Sept. 1997.
3. Yu-Li Huang - "Spatial and temporal variation in pollutant concentrations: implications for exposure and risk assessment of airborne pollutants," Ph.D., Environmental Health Sciences, Dec. 1999. Associate Professor, Dept. of Safety, Health and Environmental Engineering, National Kaohsiung University of Science & Technology, Kaohsiung City, Taiwan
4. David Bowman - "Analysis of contaminant loss pathways from Great Lakes confined disposal facilities" (not completed)
5. Andrea Jensen - "Application of environmental performance standards for siting and capacity assessment of hazardous waste facilities" (not completed)
6. Alok Mittal - "Models of bioventing processes for remediation of VOCs in unsaturated soils" (Civil Engineering).
7. Christopher Godwin – "Indoor air quality and human health in large mechanically ventilated office buildings," Ph.D., Environmental Health Sciences, Jan. 2003.
8. Erin Drury – "Environmental risk assessment and communication" (not completed)
9. Chu-Yun Huang -- "Gas phase filtration for indoor air quality" (not completed)
10. Tricia A. Metts – "Filtration of Ozone by Carbonaceous Materials: Removal Efficiencies and Reactions with Volatile Organic Compounds", Ph.D., Environmental Health Sciences, Dec. 2004. Associate Professor, Department of Environmental Health, East Tennessee State University.
11. An-Tsun Huang, "Formation, Fate and Risks of Disinfection Byproducts in Food and Water," Ph.D., Environmental Health Sciences, Jan. 2005. Director of Coordinating Services, Cancer Control Program, Lombardi Comprehensive Cancer Center, Georgetown University.
12. Christopher Bradlee, "PBPK Modeling of Chemical Mixtures" (not completed)
13. Hien Q. Le, "Exposure and impacts of air pollutants on adverse birth outcomes in Michigan" (2004 – 8), May, 2008. Research Investigator, E.I. du Pont de Nemours and Company, Wilmington, DL.
14. Chunrong Jia, "VOC Risks and Exposures in Three Detroit Area Communities," Ph.D., Environmental Health Sciences, April 2007. Asst. Prof. Environmental Health, University of Memphis, Memphis, TN.
15. Mamopeli Matooane, "Assessment of Risk to Air Pollution in the South Durban Basin," University of Natal, Durban, South Africa, Feb. 2004-
16. Kai Zhang, "Exposures and Health Risks Due to Traffic Congestion," Ph.D., Environmental Health Sciences, May, 2010. Assistant Professor, Division of Environmental & Occupational Health, University of Texas School of Public Health, Houston, TX
17. Jo-Yu Chin, "Characterization of biofuels blends: emissions, permeation and apportionment of volatile organic compounds." Ph.D., Environmental Health Sciences, May, 2011. Researcher, New York State Department of Health.
18. Robert Knonowech, TBD. (2008 - 2010) (not completed)
19. Lei Huang, EHS, Polycyclic Aromatic Hydrocarbons (PAHs), Nitro-PAHs and Petroleum Biomarkers in Lake Michigan (2010-14).
20. Liuliu Du, Efficiency and use of stand-alone filters in residential environments, School of Environmental Science and Engineering, Donghua University, Shanghai, China. EHS (2009 - 2012)
21. Feng-Chiao Su (Jo-Su), Exposures to mixtures of air pollutants: Analysis of biological, personal and area monitoring, EHS (2008 - 2015). Post-doctoral fellow. University of Michigan. California Air Resources Board.
22. Joana MF Bastos, "Integrating urban design and sustainable development: Life-cycle energy and greenhouse gas emissions from urban residential patterns." Sustainable Energy Systems, University of Coimbra, Portugal. July 2012 – Dec. 2017.

23. Lei Huang. Polycyclic aromatic hydrocarbons (PAHs), nitro-PAHs and petroleum biomarkers in Lake Michigan. (2010-2014). Post-doctoral fellow. University of Michigan.
24. Chad Milano, "High resolution dispersion modeling and exposure estimation," UM, 2014-9
25. Sheena Martinez, "Development of exposure and health metrics to guide environmental policy," UM, 2014-8

Co-Chair - as primary advisor

1. Paul Milne - "The measurement of the diffusion rates of volatile organic compounds through laboratory-prepared and intact soils", Ph.D., Chemistry, May 1996.
2. João Carrilho – "Measurement of infiltration rates in buildings", Ph.D., University of Coimbra, Coimbra, Portugal (expected 2015).
3. Shi Li, TBD, Biostatistics (2008 - 2013). Statistician at Eli Lilly and Company, Indianapolis
4. Lawrencia Kwarteng, University of Ghana, "Exposure at an E-waste site", April 2017 – present.
5. Amelia Grant-Alfieri (2019-) examining exposures and mid-life disease outcomes under Dr. Parks and Batterman.

Member

1. Diana Tsimis - "A kinetic model for the biostrip process," Ph.D., Civil Engineering, 1989
2. Rudi Luyendijk - "Microscale impact assessment of the Dutch deltaplan reclamation project using empirical modeling techniques," Ph.D., Civil Engineering, 1991
3. Jeffrey Brook - "A meteorology-based approach to detecting response source-receptor relationships," Ph.D., Atmospheric, Oceanic and Space Sciences, May 1991
4. Joseph Helfand - "Comprehensive biologically based carcinogenic models as tools for risk management of environmental chemicals," Environmental and Industrial Health, 1993.
5. Steven Michael - "The development of the quadrupole ion trap storage/reflectron time-of-flight mass spectrometer," Ph.D., Chemistry, March 1994
6. Daniel H. Anna, "Modeling the permeation of organic solvents through polymeric chemical protective clothing," Ph.D., Environmental and Industrial Health, May, 1997.
7. Heather Smith-Cismoski - "Vector modeling of separations for high speed gas chromatography with pressure tunable selectivity," Ph.D., Chemistry, 1998
8. Pertti Pasanen - "Hygiene of ventilation systems in office buildings: emissions of filters and cleanliness of air ducts," Faculty of Natural and Environmental Sciences, University of Kuopio, Kuopio, Finland, Ph.D., August 1998.
9. Mukesh Khare - "Air quality modeling for an urban road intersection of Delhi City", Civil Engineering, Indian Institute of Technology, Ph.D., 1999.
10. Erich D. Steinle - "Potentiometric and spectroscopic studies of metalloporphyrin-based polymer membranes, Ph.D., Chemistry, Oct. 1999.
11. Jeong Yeon Nah – "Application of SAW sensors for VOC mixtures," expected 1999.
12. Karen L. Skubal – "Effect of field geochemical and microbiological parameters on trichloroethylene biodegradation by indigenous bacteria in natural and amended soil systems," Civil and Environmental Engineering, 2000.
13. Q. Shiang Fu, processes affecting the fate of dioxins in the environment: microbial and chemical reductive dechlorination of polychlorinated dioxins", Civil and Environmental Engineering, 2000.
14. Guibo Xie, "Evaluation of reactive redox capacity for subsurface petroleum contamination remediation design and operations," Civil and Environmental Engineering, Oct. 2001.
15. Chia-Jung (Vincent) Lu, "A portable analytical system employing tunable separation and microsensor array detection for indoor air quality monitoring, Industrial Hygiene," expected 2002.
16. Jae Chang, "Local environmental control manager for underfloor air supply system, Architecture and Urban Planning," expected 2002.
17. Sharad Gokhale, "A hybrid model for prediction of carbon monoxide from vehicular exhaust in urban environment," Environmental Engineering Group, Civil Engineering Department, Indian Institute of Technology, New Delhi, India, expected 2003.

18. Chongzheng Na, "Mechanistic and kinetic study of cyanogen halide formation from amino acids using membrane introduction mass spectrometry, Civil and Environmental Engineering, Nov. 2003 –
19. Mamopeli Matooane, "Assessment of Risk to Air Pollution in the South Durban Basin," University of Natal, Durban, South Africa, Feb. 2004-
20. Dennis Crespo Matos, Adsorption properties of carbon nanotubes, Mechanical Eng. 2004-
21. Qiongyan (Judy) Zong, "A portable gas chromatograph employing novel approaches to sample capture, separation, and detection for trace-level determinations of complex environmental vapor mixture components, Ph.D., Environmental Health Sciences, May, 2008.
22. Sun Kyu Kim, "Microanalytical systems for complex vapor mixtures – development and application to indoor air contaminants and breath biomarkers (2009 -).
23. Matthew W. Spears, "Modeling the Equilibrium Phase Partitioning of Freshly Diluted Internal Combustion Engine Exhaust, Mechanical Engineering", (2011 -) Research Engineering at US EPA.
24. Ana Sofia Mendes, Indoor Environment and Health Related Quality of Life in Elderly Assisted Living Residences, Environmental Health Department, National Health Institute, Porto, Portugal (2010-)
25. Thitiporn Sukaew, Micro-scale preconcentrators for vapor-phase air contaminants: optimizing the design and operating conditions for integration with micro-scale gas chromatographic instrument. EHS (2007 – 13)
26. Nkosana Jafta, "Allergens and indoor environment in low and middle incomes homes in Durban, South Africa, Dept of Environmental and Environmental Health, University of KwaZulu Natal, Durban, South Africa (2007-14)
27. Yun Xiang, "Mobile Sensor Network Design and Optimization for Air Quality Monitoring. Electrical and Computer Engineering, UM, 2012-13.
28. Shi Li, "Bayesian Modeling for Environmental Association and Gene-Environment Interaction Under Complex Epidemiologic Study Designs." Biostatistics, School of Public Health, 2011-13.
29. Joao Carrihlo, Air exchange rate determinations. Sustainable Energy Systems, University of Coimbra, Portugal. 2014-.
30. Cedric Wannaz, "Local to global multi-scale multimedia modeling of chemical fate and population exposure," Environmental Health Sciences, University of Michigan, 2009-2017.
31. Zoey Laskaris, TBD, Epidemiology, School of Public Heatlh, 2017-
32. Xin Wang, "Heavy metal exposures and type 2 diabetes among midlife women," Epidemiology, School of Public Health, 2018-.
33. Ning Ding, "Persistent organic pollutants and age of menopause among midlife women," Epidemiology, School of Public Health, 2018.
34. Paolo Filigrana, "Air Pollution and Health Impacts from Vehicle Emissions," Epidemiology, School of Publc Health", 2017-2019.
35. Weilin Liao, "Progressive Cellular Architecture in Microscale Gas Chromatographs for Broad Chemical Analyses," Electrical Engineering, UM, 2020-

<u>Doctoral Pre-Candidate Qualifying and Research Committees</u> (in addition to above) - (29)

1. Lenly Weathers - Civil Engineering, 1987
2. Malali Ravindra - Civil Engineering, 1987
3. Joseph Ernest - Civil Engineering, 1987
4. Andrew Ernest - Civil Engineering, 1987
5. Gwy Am Shin - Environmental Health Sciences, 1992
6. Nam Won Paik - Industrial Health, 1992.
7. Tser-Chen Lin - Environmental Health Sciences, 1993.
8. Jeffrey Haskins - Environmental Health Sciences, 1994
9. Myoung-Jin Kim - Environmental Health Sciences, 1995
10. John MacArthur - Environmental Health Sciences, 1996; 1997
11. Robert Trombley – Environmental Health Sciences, 1998; 1999
12. Janice Lee - Environmental Health Sciences, 1999

13. Wei-Chang Su – Environmental Health Sciences, 1999
14. Erin Drury – Environmental Health Sciences, 1999
15. Laura Brixley - Environmental Health Sciences, 2000
16. Maria Rosario -Environmental Health Sciences, 2000
17. Simin Abrishami - Environmental Health Sciences, 2000; 2001
18. Jamie Meliker - Environmental Health Sciences, 2001
19. Tarino Charleson - Environmental Health Sciences, 2000; 2001
20. Yoo, Sang-Joon - Environmental Health Sciences, 2001
21. Sheryl Kennedy – Environmental Health Sciences, 2002
22. Yi-Chen (Jane) Wu – Environmental Health Sciences, 2003
23. Ronke Soyombo – Environmental Health Sciences, 2003
24. Sang Yoo – Environmental Health Sciences, 2003
25. Melissa Slotnick – Environmental Health Sciences, 2003
26. Mary Johnson – Environmental Health Sciences, 2003
27. Zorimar Rivera – Environmental Health Sciences, 2004
28. Luis Omar Rivera-Gonzalez – Environmental Health Sciences, 2004
29. David Choi – Environmental Health Sciences, 2005
30. Syu-Ruei Jhang. – Taiwan University, 2017-8.

Master's Thesis Research Committees

<u>Chair</u>

1. Pinakin Patel - "Modeling the movement of VOCs in the vadose zone" M.S., Civil Engineering, Feb. 1989
2. Dow J. Zabolio - "Decentralized water demand management," MS, Civil Engineering, May 1989
3. Lenly Weathers - "The design of a groundwater flowmeter," MS, Civil Engineering, February 1989
4. Harriet P. Shannon - "The determination of area source emission factors using whole air sampling," MS, Civil Engineering, November 1989
5. Xiao-Fang Yang - "Gaseous and particulate contamination in space" MS, Mechanical Engineering, December 1989 (Co-chair)
6. Nancy Bartoletta - "Fungal volatiles of potential relevance to indoor air quality, MS, Environmental Health Sciences, May 1991
7. Brian McQuown - "Development of a Passive Soil Gas Flux Sampler," MS, Civil Engineering, December 1991
8. Adarsh Kulshrestha - "Modeling the fate and transport of volatile organic compounds in the vadose zone," MS, Environmental Health Sciences, September 1991
9. Ganda Glinsorn - "Determination of FTIR detection limits for volatile organic compounds, MS, Environmental Health Sciences, April 1992
10. Matthew Pickus - "Dose delivered from a tritium contamination in a laboratory environment," MS, Environmental Health Sciences, April 1997.
11. Mary Lou Davis - "Surgical suite medical waste audit: a case study at the University of Michigan Medical Center"
12. Norton Fogel - "Comparison of remediation approaches for TCE in unsaturated soils: a field study"
13. Paige Davis - "Adequacy of environmental reporting: a case study and the Fortune 50, MS, Environmental Health Sciences, June, 1994
14. Jonathan Greene - "Application of pollution prevention and life cycle design principles to an evaluatory framework for chemical production and utilization," MS, Environmental Health Sciences/Industrial Hygiene, July, 1996.
15. Michael Martinko - "Adequacy of IH monitoring plan at a petroleum refinery", MS, Occupational Health, Dec., 1995
16. Kimberly MacLaren - "Development and evaluation of an industrial hygiene exposure assessment model" MS, Environmental Health Science, expected June, 1996
17. Igor Osak - "Characteristics of existing and potential filter media for high volume air samplers," MS, Environmental Health Science," May, 1996

18. John MacArthur - “Uncertainties in the Use of a Mass Balance Framework to Characterize Industrial Emission from Process Vessels” July, 1996
19. Donald K. Ward, “Estimating metal emissions from a cement manufacturing facility burning liquid hazardous waste using soil monitoring and deposition predictions,” MS, Environmental Health Sciences, Dec. 1997.
20. Katherine Sadowski, “Measurement and analysis of EMF from microwave towers,” MS, Environmental Health Sciences, May, 1998.
21. Eugene Mei, “Developing measurable goals for reductions in polycyclic aromatic hydrocarbon loadings to Boston harbor sediments,” MS, Environmental Health Sciences, May, 1998.
22. James Warila, “Ecological risk assessment of silver effluents in aquatic systems,” MS, Environmental Health Sciences, Sept. 1998.
23. Jeffrey Edge, “Needs assessment for hazardous waste and industrial hygiene programs,” MS, Industrial Hygiene, May, 1999.
24. So-Young Lim, “Evaluation of aerosol sampling using pressure drop across pore-type filters, MS, Environmental Health Sciences, May, 1999.
25. Nancy Sachs, “Environmental life cycle impact analysis”
26. Shoba Prandoh, “Temporal measurements of air quality and relationship to sources in a dental office,” MPH, Environmental Health Sciences, July 1999.
27. James Braun, “VOC exposures during commuting,” MS, Industrial Hygiene, May, 2000.
28. Chad Bailey, “Environmental justice studies”
29. Anthony Barnes, “Environmental health protection in South Africa”
30. Dana Lee, “Analysis of job classification hazards at a large pharmaceutical firm (tentative).
31. Gregory Lower, “Receptor modeling of VOCs in Detroit (tentative)
32. Carrie Ziehl, “Multipoint Monitoring and Assessment of VOCs, CO_2, O_3, and NO_X Concentrations in An Office Building, MS, Environmental Health Sciences, Sept., 2001.
33. Emily Barnet, “Air quality and exposures at an off-set printing facility”
34. Cindy Harms, “Air quality and worker symptoms and perceptions at an off-set printing facility”
35. Erika Kovacs, “Revisiting the threshold quantity criteria in the US EPA risk management program”
36. Joy Kistnasamy, “Health effects of learners and teachers at the Settlers School in South Durban associated with ambient air pollution” Department of Environmental Health, Technikon Natal, Durban, South Africa.
37. Nitasha Baijnath, “Short Term Exposure Measures For Acute Respiratory Health Effects Among Learners and Teachers at Settlers Primary School in South Durban,” Department of Environmental Health, Technikon Natal, Durban, South Africa.
38. Lynn Zwica, “The Effect of Ozone Concentration and Humidity on the Removal Efficiency and Surface Area of Activated Carbon,” 2002.
39. Amy Lynne Kascewicz, MPH, 2002 - 2005
40. Sonja A. Rawie, Sonja A. Rawie, “Development of Externality Costs Using Conjoint Analysis and Expert Opinions,” 2002.
41. Dang Nguyen (Environmental Health Sciences)
42. Shalonda Lynnise Hunter (Urban Planning)
43. Yang-won Suh, “THMs in pools”
44. Yungdae Yu, “Evaporative emissions from vehicle fuel cap assemblies”
45. Tim Kennedy (Environmental Health Sciences)
46. Beth Hedgemen
47. Michael Rosenow (Environmental Health Sciences, OJOC, Nov. 2003 -)
48. Gina Hatzivasilis, "Concentrations of volatile organic compounds and air exchange rates in residences and attached garages," July, 2005.
49. Yi-Chen Wu, “Proximity of schools in Detroit to highways.” July, 2005.
50. Angela Fuller, MS
51. Qin Wei Chow, MPH

52. Kevin Bolon (SNRE), 2007
53. Keita Fujihira (SNRE), 2007
54. Tze-Chun Chen, Performance Evaluation of a Medium Flow Sampler for Airborne Brominated Flame Retardants (BFRs), MS, 2008.
55. Scott Schroeder, "CO concentrations in ice rinks in Michigan. MPH, 2008
56. Hudda Elasaad, "A gradient study of PAH deposition near roads, MS, September, 2011.
57. Savitha Sangameswaran, "Sources and factors influencing airborne particulate matter in Detroit, MI" (expected October 2011).
58. Dongyan Sun, TBD, expected May 2012.
59. Yu Yu, Environmental risk factors and amyotrophic lateral sclerosis (ALS): A case-control study of ALS in Michigan, March, 2013.
60. Nan Yan, "Intervention and IAQ studies," UM, 9/1/17 -

<u>Member</u> - (11)

1. Evan Cook - "Diffusion of contaminants through landfill liners," MS, Civil Engineering, 1989
2. James W. Askew - "Computer aided cyclone analysis," MS, Agricultural Engineering, 1989
3. John D. Watts - "Flow instrumentation for porous media simulator," MS, Civil Engineering, 1990
4. Jaebum Choi - "Development of soil/air flux measurement instrumentation" M.E., Mechanical Engineering, 1992
5. Graham Barratt, "Mercury dispersal and uptake resulting from Thor Chemical," M.S., Environmental and Industrial Health (1999).
6. Mark Huang, "Surface acoustic wave sensor applications" (tentative)
7. John Raflowski, "Evaluation of agricultural uses of foundry sand" (tentative)
8. Michael Lane, "Risk assessment at a gasification site" (tentative)
9. Shanna Schmiesing, "Artificial Neural Network Analyses of Microsensor Array Response Patterns", 2004.
10. Juliet Merts, "Using measured road tunnel air concentrations to verify mobile source emission factors embedded in the IPIECA toolkit and to speciate total hydrocarbons," Peninsula Technikon, Cape Town, South Africa, 2004 (visit to University of Michigan, 7/1/2002 – 12/28/2002.)
11. Ashish Jachak, "Indoor pollutant concentrations – A non steady state approach," M.S., Environmental Health Sciences (OJ/OC), 2005.
12. Peter Dornbos MS, Mercury exposure and neurochemical biomarkers in multiple brain regions of Wisconsin River Otters (Lontra canadensis) (May, 2012).

<u>Master's Students Research Projects </u>(non-thesis) - (10)

1. Mary Dawn Azizian - "Emergency response planning and air quality modeling" MPH, Environmental Health Sciences, May 1992
2. Hsiang-Yin Chen - "The treatment of hospital solid wastes", MPH, Environmental Health Sciences, May 1992
3. Chia-Chin Cheng - "Hazard analysis for the transport of hazardous waste transportation in the University of Michigan, MPH, Environmental Health Sciences, April 1993
4. Jeffrey Hartford - "Analysis of particulate releases using duct monitoring", MS, Occupational Health, May, 1994.
5. Paris Watson - "The role environmental/health education should play in the control of schisosomiasis", MPH, Environmental Health Sciences, April, 1993.
6. Richard Martin - To be determined.
7. Shannon Armijo – "A review and critique of questionnaires for indoor air quality investigations," MPH, May, 1999.
8. Megan McMaster, TBD
9. Adrienne Kari, MPH, 2005.
10. Josh Bennet, MPH 2005
11. Bradley Lampe, MPH (2005-6)
12. Jung Eun Lee, MS, Biostatistics (2008)

13. Shannon Hamilton (2016-8)
14. Siyao Lu, MPH (2015-7)
15. Christopher Schaitkin (2016-7)
16. Samantha Becker (2016-8)
17. Alextia Armstrong (2017-9)
18. Cally Xi (2018-)

<u>Additional Graduate Students Supervised</u> (since 1989, 15)

1. Haza Rashid Hammad - 1989-90
2. Kimberly Osborn - 1989-90
3. Elizabeth Esseks - 1992
4. Ji-Young Lee - 1992-3
5. Michael Dojka - 1993
6. Anthony Barnard - 1993-
7. Jim Hensley - 1994-
8. Barbara Zabawa - 1994-5
9. Iyer Padmanabham - 1994-5
10. Roxanne Present - 1995-6
11. Stephanie Franke - 1996-7
12. Vernon Fillis, "Bioreactors for chlorinated solvents in water, Chemical Engineering, Peninsula Technikon, Bellville, South Africa, visiting University of Michigan, 1/2000 – 8/2000.
13. Greg Hangone, "Life cycle assessment for bagasse," Chemical Engineering, Peninsula Technikon, Bellville, South Africa, visiting University of Michigan, 7/2001 – 12/2000.
14. Philemone Simelane, "Numerical modeling of smart actuators, Mechanical Engineering, Peninsula Technikon, Bellville, South Africa, visiting University of Michigan, 7/2001 – 12/2000.
15. Henrich Amsterdam, "Dispersion Modeling of Air Pollution Sources in the Durban South Industrial Basin" Chemical Engineering, Peninsula Technikon, Bellville, South Africa, visiting University of Michigan, 7/1/2002 – 12/28/2002, MS awarded Jan. 2005.
16. Nathan Craig; Laboratory Rotation, Winter, 2017.

Undergraduate Advising – Undergraduate Research Opportunities Program and Others

1. Artesha Joy Ervin – 2001 – 2
2. Ugo Okwumabua – 2002
3. Scott Roberts – 2005
4. Mariesha Lala -- 2012
5. Jennifer Liu -- 2012-3
6. Eva Greenthal – 2013
7. Jordan Mencer – 2014-7
8. Naya Grier– 2016-7
9. Anthony Chen– 2016-7
10. Colin Palaciosrolston – 2016-7
11. Kareem Sharabi – 2017 – 2018
12. Kori Maxie – 2017 – 2018
13. Elizabeth Ratajczyk – 2017 – 2018
14. Victoria Bankowski – 2017 – 2018
15. Emily Meza-Wilson – 2018-2019
16. Sanghoon Kim – 2018-2019
17. Sarah Sukal – 2018

18. Sophia Hamelink – 2018-2019
19. Megan Bader – 2018-2019

PostDoctoral Advising

1. Dr. Ling Yu He - Analysis of VOCs in ambient air, 1988
2. Dr. Dr. George Moridis - Analysis of moisture and heterogeneities in soils, 1988-9
3. Dr. Quilin Chang - Analysis of VOCs in soils, 1991
4. Dr. Nicola Pirrone - Indoor air quality and ambient particulate deposition, 1991-3, Director, Institute of Atmospheric Pollution Research, Rome, Italy.
5. Dr. Hong-Kui Xiao - Analysis of VOCs in biological specimens, 1993-6
6. Dr. Guo-Zheng Zhang - VOC analysis related to indoor air quality and wood products, 1993-6
7. Dr. Minghao Zhao - Fast GC and microbial VOC analysis - 1997
8. Dr. Shuqin Wang - FTIR and indoor air - 1997 - 2001
9. Dr. Lianzhong Zhang - Disinfection byproducts - 1997 - 2001
10. Dr. Chung Peng - VOC analyses - 1998 – 2000
11. Dr. Christopher Godwin – IAQ analyses – 2003
12. Dr. Jae Hwan Lee – VOC analyses – 2004-2005
13. Dr. Sergei Chernyak – VOC and other organic analysis – 2004 –
14. Dr. Simone Charles – 2005 – 2007, Associate Professor, Michigan State University, Flint, MI
15. Dr. Chunrong Jia, 2008 – 2009, Associate Professor, University of Memphis, Memphis, TN
16. Dr. Jo-Yu Chen, 2011-13, Research Scientist II, Office of Quality and Patient Safety, New York State Department of Health, Albany, NY
17. Dr. Rajiv Ganguly, 2012-13. Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh, India
18. Dr. Feng-Chiao Su, 2013-16. Epidemiology Services Branch, NIOSH, Morgantown, WV (2016 – 8), Research Division, Population Studies Section, California Air Resources Board.
19. Dr. Liuliu Du, 2012-13
20. Dr. Sarah Le, 2014
21. Dr. Owais Gilanni, 2014-6, Assistant Professor, Bucknell University, Lewistown, PA (2016-8).
22. Dr. Lexuan Zhong, 2015-2017. Assistant Professor, University of Edmonton, Edmonton, Canada (2017-).
23. Dr. Daniel Katz, 2016-2019
24. Dr. Nan Lin, 9/1/2017 – present
25. Dr. Stephen Goutman, 9/1/17 – present
26. Dr. Simone Charles, 9/1/18- present
27. Dr. Sung-Hee Seo, 1/1/20-present

Sabbatical and Visitor Advising/Support

1. Dr. Eugene Cairncross, Peninsula Technikon, Bellville, South Africa (4/1/00 – 9/30/00)
2. Prof. Bohua Sun, Peninsula Technikon, Bellville, South Africa (7/30/00 – 8/3/00)
3. Prof. Pentti Kalliokoski, University of Kuopio, Kuopio, Finland (8/1/00 – 7/30/01)
4. Prof. Milan Carsky, University of Durban-Westville, South Africa (7/1/01 – 8/20/01)
5. Dr. Olga Mayan, National Institute for Environmental and Occupational Health (3/16-23/03)
6. Prof. Fausto Freire, University of Coimbra (2/28/08 – 8/15/08)
7. Mr. Peter Mochung Mochungong, Institute for Public Health, University of Southern Denmark (12/27/09-6/25/10)
8. Dr. Liuliu Du, Associate Researcher, School of Environmental Science and Engineering, Donghua University, Shanghai, China. (9/09 –)
9. Dr. Raghavan Sampathraju, Indian National Institute for Occupational Health, Delhi, India, 1/1/12-6/30/12.
10. Dr. Lizhong Xu, Fujian Normal University, Fujian, China, 8/14/15-8/15/16.

Other

Minority International Research Training Program

1. Joy Ervan – 2002 – placement in Chile

Summary of Academic Advising

Post-doc supervision/committee chairs/cochairs/members

	Post-doc supervision	***PhD Committee Chairs***	***PhD Com. Memberships***	***MS Theses/Project***
Total	*20*	*20 (includes 1 co-chair)*	*22*	*57*

***Total number of advisees** (since 1986, graduate only (requires updating)/)*

PhD/DrPH Research Committee	*42*
Qualifying Exam Committee (excluding above)	*29*
MS/MPH Research Committee	*64*
Other MS/PhD	*26*
Post-doctoral fellows	*22*
Sabbatical and visitors	*3*
Total students/postdocs advised	*180*

SERVICE

Professional Memberships and Offices

1. Member, Air and Waste Management Association (1982-)
2. Member, American Society of Testing & Materials, Committee D-22 on Sampling & Analysis of Atmospheres (1986-99)
3. Member, American Geophysical Union (1987-93)
4. Member, Association of Environmental Engineering Professors (1987-95)
5. Member, American Association for Aerosol Research (1989-91)
6. Advisory Board Member, Association of Professionals Involved with Non-Utility Power Generation (1990-96)
7. Associate Member, American Society of Heating, Ventilating and Refrigeration Engineers (1992-5)
8. Chairman, U.S. Working Group on FTIR Spectroscopy for the Measurement of Air Pollution, International Organization of Legal Metrology (March 1992-5)
9. Member, National Environmental Health Association (2000 -)
10. Associate Editor, *ASCE Journal Environmental Engineering* (air pollution topics) (2002-5)
11. Member, International Society for Environmental Epidemiology (2002 -)
12. Editorial Board, *Journal of Environmental and Public Health*, http://www.hindawi.com/journals/jeph/ (2008 -)
13. Member, (External) Scientific Advisory Board of the Energy for Sustainability (EfS) Initiative, University of Coimbra, Portugal (2013 -)

Journal, Book and Abstract Reviews

1. *Soil Science Society of America* (1997)
2. *Air and Waste Management Association* (formerly Air Pollution Control Association) (1988-)
3. *Journal of Environmental Management* (1991-)
4. *Atmospheric Environment* (1991-)
5. *Environmental Science and Technology* (1992-)
6. *Water Research* (1992-)
7. *Journal of the American Industrial Hygiene Association* (1993-)
8. *The Science of the Total Environment* (1994-)
9. *ASCE Journal of Environmental Engineering* (1994-)

10. *Choice*, Association of College and Research Libraries, American Library Association (published 4 college textbook reviews in 1997-8; 4 in 1998-9; 2 in 1999-0)
11. *The Michigan Academician*, Michigan Academy of Science, Arts and Letters (1998-)
12. *Environmental Practice*, the National Journal of the Association of Environmental Professionals (1999-)
13. *Journal of Industrial Ecology* (2000-)
14. *Indoor Air* (2000-)
15. *International Society of Exposure Analysis/International Society for Environmental Epidemiology* (2002)
16. *Environmental Research* (2005-)
17. *Environment International* (2007-)
18. *Others…*
19. *Peer reviewer (2016-17), e.g., Air and Waste Management Association, Atmospheric Environment, Environmental Science and Technology, Indoor Air, The Science of the Total Environment, Environment International*

Book and Report Reviews for Other Institutions

1. US EPA (various reports and conference paper reviews (1998-)
2. National Research Council, Transportation Research Board (conferences and journals, 1997-)
3. US EPA National Pollution Prevention Center, book and report review, e.g., <u>Overview of Environmental Problems</u> (1995)

Grant and Proposal and Other Reviews

1. US Department of Energy, Appropriate Technology Small Grants Program (1982, 1983)
2. Environmental Protection Agency, Atmospheric Research & Assessment Peer Review Program (1988, 1990)
3. Department of Energy, Office of Health and Environmental Research, Climate Research Program, Small Business Innovative Research Grants Program (1991, 1992, 1993).
4. Environmental Protection Agency, Science and Engineering Environmental Research Program (1993)
5. Great Lakes Research Protection Fund (March, 1995)
6. National Science Foundation NATO Advanced Study Institute Program (Sept. 1995).
7. US Environmental Protection Agency, National Exposure Research Laboratory, Internal Grants Program, (Sept.-Oct. 1995).
8. US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Center for Environmental Research and Quality Assurance, Graduate Education Fellowship programs (Feb. 1996).
9. US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Exploratory Environmental Research Program (June, 1996).
10. Center for Indoor Air Quality (June, 1996; June 1997; June 1998).
11. Research Grants Council of Hong Kong, University Grants Committee (March, 1997; February 1998; April 1999, March 2000; December 2000; March 2001; February 2003, February 2004; May 2005, April 2010; October 2012).
12. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Environmental Engineering, Exploratory Grants Program (June, 1998).
13. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Environmental Monitoring for Public Access and Community Tracking (EMPACT) Grants Program (July, 1998).
14. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Graduate Environmental Study Fellowships (March, 1999).
15. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Graduate Environmental Study Fellowships (January, February, 2000).
16. Panel Member, Office of Life Sciences and Microgravity Sciences, NASA Extramural Grants Program (March, 2000)
17. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Futures Research in Socio-economics (Sept. 2000).
18. Research Management Group, Linthicum Heights, MD (December, 2000).

19. Panel Member, US National Institute of Occupational Health and Safety, Hazardous Substances Training and Hazardous Substances Academic Training Programs (September 2001).
20. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Graduate Environmental Study Fellowships (Jan. – Feb. 2002).
21. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Futures Research in Socio-Economics (Jan. 2002).
22. Panel Member, US Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, Superfund Minority Institution Research Program: Hazardous Substances Research (Oct. 2002).
23. Panel Member, US National Science Foundation, Grants Review (April – May, 2003).
24. Panel Member, International Science and Technology Center and Science and Technology Center in Ukraine Projects, US Civilian Research and Development Foundation (October, 2003).
25. Panel Member, Environmental Statistics Research: Novel Analyses of Human Exposure Related Data, US Environmental Protection Agency (April, 2004).
26. Panel Member, New Investigator Award, Health Effects Institute (May, 2004).
27. Subchair, Advanced Research in Environmental Health Special Emphasis Panel (ARCH-SEP), National Institute of Environmental Health Sciences (March, 2005).
28. Reviewer, Cooperative Grants Program (CGP) 2006 of the U.S. Civilian Research and Development Foundation (CRDF), October 2006.
29. Panel Member, US Environmental Protection Agency, National Center for Environmental Research, Uncertainty Analyses of Models in Integrated Environmental Assessments (March, 2007).
30. Panel Member, Graham Environmental Sustainability Institute; Water, Environmental and Health, Pilot Research Program (Feb. 2008)
31. Panel Member, US Environmental Protection Agency, National Center for Environmental Research, Uncertainty Analyses of Models in Integrated Environmental Assessments (March, 2007).
32. Panel Member, Advanced Research Program, Texas Higher Education Coordinating Board, Austin, TX. Nov.-Dec. 2007.
33. Panel Member, Strategic Environmental Restoration Defense Program, US Department of Defense (Vapor Intrusion), April, 2008.
34. Panel Member, Research Excellence Centers, National Research Foundation, United Arab Emirates (Oct. 2008).
35. Reviewer, Cooperative Grants Program (CGP) of the U.S. Civilian Research and Development Foundation (CRDF), April, 2009.
36. Reviewer, Institute for Population Studies, Health Assessment, Administration, Services and Economics (INPHAASE), Wayne State University, 2010.
37. Reviewer, Knowledge Foundation, Sweden. 2010.
38. Panel Member, "Exploring Linkage between Health Outcomes and Environmental Hazards, Exposures, and Interventions for Public Health Tracking and Risk Management", US EPA/CDC, Washington, DC. 2010.
39. Reviewer, "Developing Exposure Indices for Rapid Prioritization of Chemicals in Consumer Products", American Chemistry Counsel, July, 2010.
40. Member, Neurological, Aging and Musculoskeletal Epidemiology Study Section [NAME], National Institutes of Health, Washington, DC. April - June, 2013.
41. Reviewer, Development research grants, Academy of Finland, Helsinki, Finland, July - Aug., 2013.
42. Reviewer, Collaborative Research Fund (CRF), Earmarked Research Grant (ERG), Hong Kong, Feb., 2014.
43. Panel Member, National Institute for Occupational Safety and Health, Disability and Injury Disease Prevention and Control Special Emphasis Panel, July, 2014.
44. Panel Member, National Institute for Occupational Safety and Health, Disability and Injury Disease Prevention and Control Special Emphasis Panel, January, 2015.
45. Reviewer, Environmental Health Sciences Center for Urban Responses to Environmental Stressors (CURES), Wayne State University, Detroit, MI. Feb., 2015.
46. Member, Neurological, Aging and Musculoskeletal Epidemiology Study Section [NAME], National Institutes of Health, Washington, DC. April - June, 2015.

47. Reviewer, Health Canada's Clean Air Regulatory Agenda (CARA) Program, Ottawa, Canada, Jan. 2016.
48. Reviewer, Special Emphasis Panel NIH National Institute of Environmental Health Scinces, K99 Career Awards, March, 2016.
49. Reviewer, National Institute on Aging, NIH, P01 Research Program Projects, Aug-Sept. 2016.
50. Reviewer, Mount Sinai NIEHS Core Center (P30 ES023515 Mount Sinai Transdisciplinary Center on Early Environmental Exposures), Pilot Projects, Sept. 2017.
51. Reviewer, National Institute on Aging, NIH, P01 Research Program Projects, Aug-Sept. 2017.
52. Reviewer, US EPA Superfund Program, May 2018-June 2018.
53. Panel Member, National Institute of Environmental Health Sciences, NIH, P42 Superfund Hazardous Substance and Training Research Review. May-June, 2019.
54. Panel Member, National Institute of Environmental Health Sciences, NIH, Time Sensitive R21 Projects. Nov.-Dec. 2019.
55. Panel Member, American Academy of Arts and Sciences, External Review and Guidance, IDeA Network of Biomedical Research Excellence, Aug-Sept. 2020.

University Service

Texas A&M University

1. Member, Graduate Studies Committee, Department of Civil Engineering (1986-1989).
2. Member, University Computer Advisory Committee for Statistical Software (1986).
3. Member, Computer Committee, Department of Civil Engineering (1987).
4. Student Advisor (for Division), Environmental and Water Resources Engineering Division, Department of Civil Engineering (1987-8).
5. Developed database/tracking system for Environmental and Water Resource Engineering Division students (1987).
6. Participant, Institute for Innovation and Design Workshops (1987).
7. Participant, Network of University Teachers (computer assistant instruction, role playing) (1988).
8. Reviewer, University Library Learning Resources Center, for recommendation of statistical software packages (1988).
9. Member, Program Promotions Subcommittee, Graduate Studies Committee, Department of Civil Engineering (1988).
10. Member, Academic Standards Subcommittee, Graduate Studies Committee, Department of Civil Engineering (1988-9).
11. Representative, Graduate Council, Department of Chemistry Dissertation Committee (1989).

University of Michigan

1. Sponsor, High School Minority Apprenticeship Program (1991, 1992, 1993).
2. Mentor, University Mentorship Program, Office of Student Services (fall, 1991).
3. Supervisor, Undergraduate Research Opportunity Program (1992, 1994, 1995, 2001, 2002).
4. Participant, Corporate and Foundations Relations Recruitment Programs (1992).
5. Member, Science Advisory Panel, Environmental Health Affects Network, CIESIN (1992-3).
6. Participant, UV-B Conference, Environmental Health Effects Network (Feb. 24-5, 1992).
7. Member, Environmental Protection Subcommittee, Vice President Womack's Financial Affairs Committee (1992-5).
8. Member, Education and Research Center (formerly Educational Resource Center) (1993-).
9. Advisor, Occupational Safety and Environmental Health and Plant Departments on indoor air quality and building ventilation (1993-)
10. Co-coordinator for environmental case study course, Scripts Journalism Fellows Programs (1993).
11. Participant, Workshops on the Interdepartmental Institute for Environmental Science and Engineering (1994).
12. Participant, Workshop on the Future of the Automobile, Pollution Prevention Center, (1994-5).
13. Faculty Adviser, School of Natural Resources and Environment, Greening the Maize and Blue Course (1995-).

14. Moderator, Campus Environmental Management Panel (Nov. 1995).
15. Member, Promotion Committee for Dr. Andrei Barkovskii, College of Engineering (Oct. 1997-Feb. 1998).
16. Board Member, Center for Sustainable Systems, School of Natural Resources and the Environment (1998 –).
17. Member, Waste Disposal Alternatives Task Force, OSEH and the Medical Center (Feb. – Aug. 1999).
18. Member, Individually Developed Overseas Internship Award Review Committee, International Institute (March - April, 1999; Feb. 2000).
19. Member, Executive Committee, Certificate Program in Industrial Ecology, Rackham School of Graduate Studies (March, 1999-).
20. Member, Environmental Justice Program Development Committee (Nov. 1999).
21. Member, Add-hoc Transportation and Planning Committee (June 2000 – April 2001).
22. Reviewer, IIE Fulbright Campus Committee (Oct. 2000, Oct. 2001).
23. Reviewer, Office of Vice President for Research, Faculty Grants and Awards Program (Jan. 2001; May 2005; May 2006)
24. Advisor, Minority International Research Training Program, Center for Human Growth and Development (Jan. 2002-)
25. Panelist, A Strategic Integrated Assessment for Revitalizing the Role of the University of Michigan in Great Lakes Research (March 2005).
26. Panelist, Careers in Environmental Health, WISE (Women in Science and Engineering) and UIR (UROP in Residence), March 2005.
27. Panelist, Environmental Sustainability Forum (interviews and focus groups), June, August 2005.
28. Member, Search Committee, Graham Environmental Sustainability Institute, Jan – May, 2006.
29. Coordinator, Research Symposium in Water, Health and Environmental Sustainability, Graham Environmental Sustainability Institute, May – Sept. 2007.
30. Reviewer, Environmental Sustainability Multidisciplinary Research Team Grant Proposals, Graham Environmental Sustainability Institute, Mar. 2008.
31. Member, Energy Conservation Committee (Joint between Utilities; Plant Operations; Architecture, Engineering and Construction; Faculty), July 2008 – present.
32. Delegate, Universities Council on Water Resources (2008 -)
33. Faculty Associate, Program in the Environment (University-wide crossroads for undergraduate environmental study (2008 -).
34. External Reviewer, Tenure and Promotion Committee, College of Engineering (Oct. 2008).
35. Faculty advisor, Students for Jamaica, Blue Mountain Project, University of Michigan Medical School, Dec. 2008 - Jan. 2009)
36. Chair, Provost's committee, 3 year review of the Graham Environmental Sustainability Institute, Jan. – Mar. 2009.
37. Member, Advisory Board, Center for Global Health, Sept. 2009 – 2010.
38. Leader, Exposure Assessment Core, and Steering Committee Member, Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), a NIEHS P30 NIEHS Core Center (2009-present).
39. Center Director, Center for Occupational Health and Safety Engineering, a NIOSH T32 Education and Research Center (2010 – present).
40. Member, Office of the Vice-President for Research 2010 - 2012 Research Faculty Awards Selection Committee, Mar. – Apr. 2010, 2011, 2012.
41. Member, Faculty Steering Committee, Report on Sustainability at The University of Michigan, Integrated Assessment, Graham Environmental Sustainability Institute (Feb. 2010 – Dec. 2010).
42. Faculty Associate, Center for Global Health (Feb. 2011-)
43. Member, Council of Fellows, The Cooperative Institute for Limnology and Ecosystems Research (CILER/NOAA) (July 2011 -)
44. Member, ADVANCE Committee for mentoring new faculty, Civil and Environmental Engineering (Feb. 2013 2016).
45. Member, Planet Blue Team (energy conservation/sustainability) (Mar. 2011 - present).

46. Chair, SPH Planet Blue Advisory Committee to the Dean (May 2011 - 2013).
47. Member, Tenure and Promotion Committee, Mechanical Engineering, College of Engineering (2014)
48. Reviewer, Honorary Doctorate Nominating Review Committee, Provost Office (Nov. 2016).
49. Fellow, Interprofessional Leadership Fellows Program, Center for Research on Learning and Teaching (Dec. 2017 – present)
50. Member, T-32 Advisory Committee, Occupational Health Nursing Progrram, School of Nursing (Sept. 2017 – present).

School of Public Health, University of Michigan

1. Contributor (and subject and editor) for "Case Study Course Examines Envotech's Proposed Hazardous Waste Incinerator," School of Public Health *Findings Magazine* (1993).
2. Member, Ad-hoc Committee for the Internal Review of the School of Public Health (1993-4).
3. Member, Advisory Committee on Academic Programs (1995 – 1997, 2000 – 2003, 2008 – 10).
4. Member (alternate), Advisory Committee on Academic Programs, School of Public Health (1998-2003).
5. Member, Planning Committee, Second Isadore Bernstein Symposium, Fourth School of Public Health Symposium on "Genetically Modified Organisms: Public Health Implications" (scheduled for Oct. 26, 2001) (2001).
6. Member, Web Implementation Committee (2000-1).
7. Member, Public Health Information Services Advisory (PHISA) Committee (2000-5).
8. Member, Merit Database Review Subcommittee, Public Health Information Services Advisory (PHISA) Committee (March–May, 2003)
9. Facilitator, SPH Retreat, April 28, 2003.
10. Chair, SPH Ad Hoc Committee on Academic Conduct (April – May, 2003).
11. Member, Informatics and Information Technology Committee, also Informatics Subcommittee (Sept – May, 2006).
12. Member, Global Public Health Advisory Committee (Dec., 2009 – May, 2012).
13. Center Director, NIOSH T42 Michigan Center for Occupational Health and Safety Engineering (2010 to present)
14. Leader, Exposure Assessment Core, NIEHS P30 Michigan Center for Lifestage Environmental Exposure and Disease (2012 – present)
15. Member, Council on Education for Public Health (CEPH) Accreditation Taskforce, (Jan. 2017 - present).
16. Member, Council on Education for Public Health (CEPH) Curriculum Subcommittee to the CEPH Accreditation Taskforce, (Jan. 2017 - present).
17. Member, Steering Committee, Community Action to Promote Healthy Environments (Nov. 2015 – present).
18. Departmental Representative, SPH Committee on Reaccrediation for Council on the Education of Schools of Public Health (Sept. 2017 – present).

Department of Environmental Health Sciences, University of Michigan

1. Member, Governance Committee (1989-).
2. Member and Equal Opportunity Liaison Officer, Faculty Search Committee (1990).
3. Member, Curriculum Committee (1990-2000).
4. Organizer, equipment and infrastructure upgrade and maintenance. Includes ventilation systems, machine shop renovation, research and teaching instrument maintenance, computer networking, etc. (1990-).
5. Member and Chemical Hazards Safety Officer, Safety Committee (1991-4).
6. Promotions and student recruitment, including writing and editing brochures, initiating contact with potential students, etc. (1991-).
7. Member, Ad-hoc Committee for an On-Job On-Campus Program on Environmental Quality Management (1991-1992).
8. Member, William Gibson Award Subcommittee (1992).
9. Director, Hazardous Substances Academic Training Program (1993-).
10. Reviewer and Contributor, EIH/HN Reorganization Task Force Draft Plan (Dec. 94-Jan. 95).
11. Member, Toxicology Faculty Search Committee (1995-6).
12. Chair, Curriculum Committee (1995-6).

13. Member, Interprogram Activities Task Force (1995 – 1996).
14. Member, EIH Search Committee (1995-1996).
15. Member, Curriculum Committee (1997-1999).
16. Member, Advisory Committee on a Common MPH Program (1998).
17. Participant, Accreditation Board for Engineering and Technology (ABET) Site Visit to Industrial Hygiene Program, Nov. 1997; Nov. 2000.
18. Member, Admissions Committee (1999-00).
19. Member, Executive Committee (1999-).
20. Mentor, Environmental Toxicology Training Program (2000-).
21. Coordinator, SPH Staff Recognition Awards (April, 2000; April, 2001).
22. Coordinator, Departmental Orientation held Aug. 31, 2000.
23. Chair, Curriculum Committee (2000-2005).
24. Associate Chair for Academic Affairs and Development (2000-2005).
25. Acting Head, Environmental Health Program (2002).
26. Host, facilitator for visit of Dr. Olga Mayan Gonçalves, head of Environmental and Occupational Health Center at the National Institute of Health in Oporto, Portugal (Mar. 17-22, 2003).
27. Member, Retreat Planning Committee (April 2003).
28. Panelist, 40th Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Oct. 23-4, 2003).
29. Coordinator and evaluator, EHS MPH First Annual Poster Session (Oct. 24, 2003).
30. Co-Chair, Strategic Planning Committee (Dec. 2003 – March 2004).
31. Panelist, 41st Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Oct. 21-2, 2004).
32. Member, Risk Sciences and Communication Faculty Search Committee (Sept. 2004 – Apr. 2005)
33. Member, EHS Chair Faculty Search Committeee (Aug. 2004 - Apr. 2005)
34. Member, Human Nutrition Planning Committee (Dec. 2004 – Feb. 2005).
35. Member, Admissions Committtee (2005-)
36. Member, Doctoral Committee (2005-6)
37. Member, OJ/OC Planning Committee (2005-)
38. Panelist, 42nd Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Nov. 3-4, 2005).
39. Panelist, 44th Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Nov. 1-2, 2007).
40. Member, Academic Programs Committee (2007-8)
41. Chair, Professional Program Curriculum Committee (2008-11)
42. Panelist, 45th Annual Warren Cook Industrial Hygiene Discussional, University of Michigan (Oct. 23-24, 2008; 2009; 2010, 2011; 2012, 2016).
43. Member, Strategic Planning Committee (2007-8)
44. Member, Academic Degree (MS/PhD) Committee (2014-5)
45. Co-Chair, Admissions and Recruitment Committee (2014-6)
46. Member, Admissions Committee (Nov. 2014 – present)
47. Member, Environmental Toxicology & Epidemiology T32 Advisory Program (ETEP), March 2018 – Sept. 2019.
48. Director, Environmental Toxicology & Epidemiology T32 Advisory Program (ETEP), Sept. 2019 - present.

Community Service

International Service

1. Reviewer, Design of ambient air quality monitoring network for Mexico City, Movimiento Ecologista Mexicano, A.C., Mexico City, Mexico (1988).
2. Participant, Seminar on Acid Rain Control Strategies for Finland," Technical Research Center of Finland, Helsinki Finland (January 1990).
3. Participant, Hydrocarbon Measurement Intercomparison Experiment (1991-2).

4. Organizer, Cooperative agreement for U-M and the Italian National Research Council, Universita della Basilicata, Dipartimento di Ingegneria e Fisica dell'Ambiente (December 1992).
5. Wastewater Engineer/Public Health Specialist, Conference on Scientific Research In The Egyptian Universities And Its Role In Solving Developmental And Environmental Problems, Cairo, Egypt (July 1995).
6. Expert Witness, Desai Presidential Commission of Inquiry into the Sulphur Fire at AECI Somerset West, Western Cape, South Africa, Jan. 29-31, 1997 (headed by Supreme Court Justice S. Desai).
7. Advisor, Cape Air Quality Project, Cape Town, South Africa (1998-9).
8. Chair, Session EE-1c, Residual Risk -- How do we do it? Air and Waste Management Meeting 93rd Annual Meeting in Salt Lake City, June 18-22, 2000.
9. Member , US Advisory Committee, International Center To Support Training And Research In Environmental And Occupational Health In Southern Africa, University of Michigan Fogarty Grant, 9/30/01 – present. See http://www.sph.umich.edu/fogartysa/admin.html
10. Advisor, South Durban Air Quality Monitoring Project, Metropolitan Council, Durban, South Africa. (Feb. 2001-6).
11. International Coordinator, 13th Annual Conference, International Society of Exposure Analysis, Stresa, Italy. Sept. 2003.
12. Advisor, collaborator, for Dr. Patel at RS University, Raipur, India on project "VOC Studies in Central India," (July-2003)
13. Advisor for Prof. Eugene Cairncross at Peninsula Technikon, Bellville, South Africa on air quality research and curriculum development in air quality (Aug. 2003).
14. Advisor for Dr. Rajen Naidoo at University of Natal, Durban, South Africa on curriculum development in Environmental Health under Fogarty Activity (Aug. 2003).
15. Chair, Resolutions Committee, 8th World Congress on International Health, International Federation of Environmental Health, Durban, South Africa (Feb. 23-27, 2003).
16. Chair, Session AT-3a Urban Air Toxics including Nanoparticles, Air and Waste Management Meeting 98th Annual Meeting in Minneapolis, MN, June 21-24, 2005.
17. Member, Advisory Board, Center for Occupational and Environmental Health, University of KwaZulu Natal, Durban, South Africa, 2003-
18. Symposium Coordinator, "Exposure and Health Studies in Durban, South Africa," 17th Conference of the International Society for Environmental Epidemiology, Johannesburg, South Africa, Sept. 13-17, 2005.
19. External Examiner, Ph.D., University of Pretoria, South Africa, September 2005.
20. External Examiner, M.S., Cape Peninsula University, South Africa, September 2005.
21. Member and Coordinator, Energy for Sustainability (EFS) Initiative, developing two post-graduate programs in "Buildings and the Urban Environment" and "Energy Policy and Systems," University of Coimbra, Portugal, Nov. 2006 – June 2007.
22. External Reviewer, Promotion Committee, University of Kuwait, Kuwait. May, 2007.
23. Meeting organizer, Curriculum Development Workshop in Environmental Health, Center for Occupational and Environmental Health, University of KwaZulu Natal, Durban, South Africa. Funded by Fogarty International Center, University Of Michigan. July 16-18, 2007.
24. Host and Facilitator, Fulbright Scholar Program for Prof. Fausto Freire, University of Coimbra, Portugal, to visit University of Michigan, 2007-8. (awarded)
25. Host and Facilitator, Fulbright Scholar Program for Prof. Mahmoud M. Abdel-Salam, Department of Environmental Sciences, Alexandria University, Alexandria, Egypt, 2007-8 (pending).
26. Advisor, Probus Sigma Lda, (International Environmental Certification), Gois, Coimbra, Portugal (Jan. 2007-).
27. External Examiner, Ph.D., University of Kuopio, Finland, October, 2007.
28. External Evaluator, Department of Environmental Health, Faculty of Health Sciences, University of Botswana, Botswana (Oct.-Nov. 2008).
29. External Evaluator of 3 PhD proposals, Department of Mechanical Engineering, University of Coimbra (Portugal), August, 2009.
30. External Reviewer, Tenure and Promotion, National University of Singapore, Singapore (Dec. 2010).

31. External Reviewer, Tenure and Promotion, American University of Beirut, Lebanon (Jan. 2011).
32. External Examiner, Ph.D., Indian Institute of Technology, New Delhi, India (March, 2011).
33. External Reviewer, Tenure and Promotion, Universiti Sains Malaysia, Palau Pinang, Malaysia. (May, 2011).
34. Member, Program Committee, Energy for Sustainability Multidisciplinary Conference EfS, Faculty of Science and Technology, Coimbra, Portugal, 8-10 September 2013.
35. Session chair, Air Pollution and Equity, Environment and Health – Bridging South, North, East and West. Joint meeting of International Society of Environmental Epidemiology, International Society of Exposure Sciences, and International Society of Indoor Air Quality, Basel, Switzerland, August 19-23, 2013.
36. External Reviewer, Promotion Committee, Dalla Lana School of Public Health, University of Toronto, Canada. (Feb., 2014).
37. Conference Chair, Energy for Sustainability 2015 Multidisciplinary Conference (along with António Gomes Martins), Coimbra, Portugal, May 14-15, 2015. Organized by the Institute for Research and Technological Development in Construction Sciences (ITeCons) on behalf of the Energy for Sustainability Initiative of the University of Coimbra.
38. External Reviewer, Promotion Committee, National Research Foundation, Pretoria, South Africa. (June, 2015).
39. External Reviewer, Tenure and Promotion Committee, University of Toronto, Toronto, Canada, March, 2020.

National

1. Participant, Workshop on Hazardous Waste Incineration, Manhattan College, New York City (June, 1988).
2. Participant, Workshop on Intermedia Contaminants, UCLA, Santa Monica, CA (August 1988).
3. Participant, Ventilation and IAQ Workshop, U.S. Environmental Protection Agency, Raleigh NC (September 14-16, 1993).
4. Participant, National Institute for Occupational Safety and Health Annual Meeting of the Directors of Hazardous Substances Academic Training Program, Stevenson WA (February 15-17, 1994).
5. Chairman, U.S. Working Group on FTIR Spectroscopy for the Measurement of Air Pollution, International Organization of Legal Metrology (1992-4).
6. Reviewer, U.S. Environmental Protection Agency for "Field Standard Operating Procedure for the Use of Open Path FTIR Spectroscopy at Hazardous Waste Sites, Environmental Response Branch, Edison, NJ (1992).
7. Reviewer, U.S. Environmental Protection Agency for "Guidance for Capacity Assurance Planning, Capacity Planning Pursuant to CERCLA Section 104(c)(9)," Office of Solid Waste and Emergency Response, EPA530-R-94-002, Washington DC (1993-4).
8. Reviewer and editor, Air Quality Chapter, in <u>Overview of Environmental Problems</u> (book), US EPA National Pollution Prevention Center, University of Michigan (1995-6).
9. Sponsor, American Society of Heating, Refrigeration and Ventilation Engineers Scholarship, awarded to Marianna Luoma (June, 1995).
10. Member, Advisory Board, Great Lakes Environmental Justice Program (1997-).
11. Comments to US Environmental Protection Agency Science Advisory Board regarding "Cumulative Air Toxics Exposure Methodology, dated July 20, 1998 (1998).
12. Panelist, International Attempts to Protect the Environment, Town Hall Forum, moderated by US Congresswoman Lynn Rivers, Washtenaw Community College (Aug. 23, 1999).
13. External Reviewer, Tenure and Promotion Committee, St. Louis University (Sept. 1999).
14. Member, Robert E. Dougherty Educational Foundation (administers scholarships in the area of wood science, technology and forest products) (1999 -).
15. External Reviewer, Tenure and Promotion Committee, University of Illinois (July, 2000).
16. Member, Science Advisory Committee, Ecology Center and the Michigan Environmental Council (Nov. 2000-2010).
17. Advisor, Camden Regional Legal Services, Camden, NJ. (Oct., 2001 – Nov., 2005)
18. External Reviewer, Houston Chronicle (October 2004 - March 2005) on series of articles addressing toxic air pollution exposure in Texas.

19. External Reviewer, Tenure and Promotion Committee, Harvard University (March 2006).
20. Reviewer, Health benefits of vehicle emission control, Environmental Law and Policy Center, Chicago, IL, Nov 2005 - Jan. 2006.
21. External Reviewer, Committee on Appointments and Promotions, Johns Hopkins University (Sept. 2007).
22. External Reviewer, Tenure and Promotion Committee, University of California, Davis, CA (Aug. 2008).
23. External Reviewer, Tenure and Promotion Committee, Clarkson University, Potsdam NY (Sept. 2008).
24. External Reviewer, Tenure and Promotion Committee, Ohio State University, Columbus, OH (Jan. 2009).
25. Invited Panelist, US Environmental Protection Agency, Benefits of Reducing Hazardous Air Pollutants Workshop, Washington DC, April 30 – May 1, 2009.
26. External Reviewer, Promotion Committee, Robert Wood Johnson Medical School, Piscataway NJ, August 2009.
27. External Reviewer, Tenure and Promotion Committee, Stanford University, Stanford, CA (Feb. 2010).
28. Member, Board of Directors, Ecology Center, Ann Arbor, MI (June 2010 – present).
29. Member, Board of Directors, Energy Works, Ann Arbor, MI (Jan. 2011 – Jan. 2013).
30. External Reviewer, Tenure and Promotion Committee, Tufts University, Medford, MA (July, 2011).
31. External Reviewer, U.S. Environmental Protection Agency Office of Research and Development, Technical Qualifications Board (July, 2013).
32. External Reviewer, Tenure and Promotion Committee, Drexel University, Philadelphia, PA (Oct. 2014).
33. External Reviewer, Tenure and Promotion Committee, University of South Florida, Tampa, FL (Aug. 2016).
34. Member, Chemical Exposures Full Working Group, Environmental Influences on Child Health Outcomes (Nov 2016 – present)
35. Member, External Peer Review Committee, Materials to Inform the Derivation of a Water Concentration Value for Lead in Drinking Water, U.S. Environmental Protection Agency, Feb. 2017.
36. Testimony, Environmental Protection Agency, National Highway Traffic Safety Administration. Comments on "The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Year 2021–2026 Passenger Cars and Light Trucks,"Dearborn, MI, Oct. 25, 2018.
37. External Reviewer, Tenure and Promotions Committee, Simon Fraser University, July, 2019.
38. Comments regarding US EPA National Primary Drinking Water Regulations: Lead and Copper Rule Revisions, with D. Giamar. Feb. 11, 2020.
39. External Reviewer, Tenure and Promotions Committee, University of Texas at Dallas. Jan., 2020.
40. External Reviewer, Promotion Documentation Package, Center for Public Health and Environmental Assessment, U.S. Environmental Protection Agency. March, 2020.

State (selected)

1. Testimony prepared and delivered to Michigan Department of Natural Resources concerning proposed Carleton Farms waste management facility in Sumpter Township, MI (August 1991).
2. Testimony prepared for United States vs. BASF-Inmont Corp. et al., DJ90-11-3-289, concerning the Remedial Design, Remedial Action Plan, Scope of Work (SOW) and Consent Decree for the Metamora Landfill National Priorities List Site (September 1991).
3. Member (nominated), State Science Advisory Council, State of Michigan (December 1992).
4. Representative, State Site Review Board, Michigan Act 64 Hazardous Waste Act (September 1992-).
5. Technical Advisor, Technical Assistance Grant Program, Metamora Landfill National Priorities List Site, Metamora, MI (1994-8).
6. Participant, Table Top Emergency Incident Planning Exercise, Washtenaw County, MI (September 1995).
7. Technical expert (indoor air quality), Michigan Education Association (Feb. – May 1998).
8. Member, Advisory Committee, Air Toxics Project Team, Wayne County Air Pollution Control Agency, Detroit, MI (1998 - 2001).
9. Member, Community Council, Environmental Health of Arab Americans in Metro Detroit, Arab Community Center for Economic and Social Services, Dearborn, MI (2000-).
10. Advisor, Southwest Detroit Environmental Vision, regarding Detroit Intermodal Freight Terminal (Feb – May 2003).

11. Testimony to Michigan Department of Environmental Quality on proposed Ypsilanti Wastewater Incineration facility (March, 2003)
12. Peer reviewer, Michigan Department of Environmental Quality on EIS Guidelines for Toxics (Sept. 2003).
13. Board Member, Community Advisor Panel, CHASS, Detroit, MI (Nov. 2003 -)
14. Reviewer, Michigan Department of Environmental Quality on Detroit Air Toxics Initiative (DATI) Risk Assessment Report (Draft Nov. 2004; Final Nov. 2005).
15. Reviewer, Ozone Attainment Strategy for the Southeast Michigan Region, Southeast Michigan Council of Governments Task Force on Air Quality, April, 2005.
16. Reviewer, Draft Environmental Impact Assessment for the Detroit Intermodal Freight Terminal, July, 2005.
17. Reviewer, Environmental Justice Analysis for Marathon Petroleum Corporation, April 2008.
18. Member, Environmental Justice Resource Group, Department of Environmental Quality, State of Michigan. Jan. 2009-.
19. Reviewer, Draft Environmental Impact Assessment for the Detroit River International Crossing, Jan. 2011.
20. Member, Michigan Department of Environmental Quality, Air Toxics Workgroup, Lansing, MI, 2012-13
21. Panelist, with Moms Clean Air Force, Michigan League of Conservation Votes, MYR, on "Unacceptable Levels", Michigan Theater, Oct 16, 2013.
22. Member, Technical Assistance Group 3, Vapor Intrusion, The Criteria Stakeholder Advisory Group, Michigan Department of Environmental Quality, Lansing MI. June - Oct. 2014.
23. Member, Transportation Coordinating Committee, Southeast Michigan Council of Governments (SEMCOG Metropolitan Planning Organization), Detroit, MI (Sept. 2014-5)
24. Panelist, Institute for Journalism and Natural Resource (forum and tour for journalists), Delray House, Detroit, MI, Oct. 23, 2014.
25. Member, Ambient air quality community monitoring site selection and outreach working group for 48217 ZIP Code, Detroit, Michigan Department of Environmental Quality, June 2016 – August 2017.
26. Member, Demolition Task Force, Detroit Building Authority, Buildings, Safety, Environmental Engineering Department, and the Detroit Health Department, December 2016 – April 2017.
27. Assistance to State Representative Stephanie Chang regarding air quality and highway projects, January-April, 2017.
28. Assistance to State Representative Yousef Rabhi regarding indoor air quality and filters in buildings, March-April, 2017.
29. Member, Emissions and Health Monitoring Technical Advisory Committee, City of Detroit and State of Michigan, Aug. 2017 – present.
30. Review and comments to Drinking Water and Municipal Assistance Division, Michigan Department of Environmental Quality, regarding proposed rules to change the Lead & Copper Rule Requirements, March 19, 2018.
31. Testimony, Michigan Department of Environmental Quality, Comments to MDEQ regarding the draft Permit to Install for Trenton Refined Coal, LLC (B2811), proposed November 13, 2018, proposed Permit No. 151-18, Trenton, Channel, MI, Dec. 18, 2018.
32. Member, Statewide Drinking Water Advisory Council, Michigan Department of Environmental Quality, 2018-2021.
33. Co-Leader, Buildig a Healthy Environment Working Group for development of an ordinance concept for Detroit entitled: Safe, Green and Healthy Development in Detroit, Wayne State Universsity, Nov. 2019-Apirl 2020.

***Expert Witness** (partial list)*

1. NAACP vs. J. Engler, Genesee County Circuit Court, Flint, Michigan. April, 1997. (Decided May 29, 1997). Hazardous waste and air quality.
2. Desai Presidential Commission of Inquiry into the Sulphur Fire at AECI Somerset West, Western Cape, South Africa, Jan. 29-31, 1997 (Decided May, 1998). Air quality, emergency response, epidemiology.
3. State Office of Administrative Hearings No 582-97-499. TNRCC Docket No. 96-1466-IHW, In the Matter of the Application of TXI Operations, L.P. For Permit No. HW-50316-00001, Dec. 1997-April, 1998. Hazardous waste and risk assessment.
4. South Camden Citizens in Action v. New Jersey Department of Environmental Protection et al. (April 2005).
5. Citizens Against Pollution v. American Electric Power Co., Inc. (Jan. 2005 - Sept. 2006). Air quality.

6. Natural Resources Conservation Board, Friends of Lamont County, Alberta, Canada (Jan. 2009 – April 2009). Sulfur storage and risk assessment.
7. Energy Resources and Conservation Board, Alberta, Canada (Sept. 2010 – Dec. 2010). Sour gas well and pipeline exposure and risk assessment.
8. Energy Resources and Conservation Board, Alberta, Canada (July - Dec. 2011). Gravity assisted oils sands extraction health risk assessment.
9. Simon Properties Group et al. v. Aon Risk Services Central, Inc., (Feb. 2012 – April. 2014). Flood damage, indoor air, and health risk assessment.
10. City of Chicago, Blotkevic v. City of Chicago, No. 2016-CH-02292 (Cir. Ct. Cook Cty. Chancery Div. (Mar. 2016 – present); Lead exposure and mitigation.
11. Bashaw Oil Corp. Alberta Energy Regulator Proceeding ID 346 (April 2017 – Dec. 2018). Health risk and hazard assessment.
12. Robert and Kerry Ellen Hart vs. Mountain West Farm Bureau Mutual Insurance Co., U.S. District Court Case CV 19-08-M-DWM (Mar. 2019 – Feb. 2020). Wildland fire exposure, indoor environment, and risk assessment.

Media: Press Interviews/Articles *(partial list)*

Interviews/articles with media regarding hazardous waste, and ambient and indoor air quality, including:

1. New York Times, Sept. 1991 (Air Toxics).
2. Sumpter County Dispatch, Oct. 1991 (Landfills).
3. Detroit Free Press, Feb. 18, 1992 (Landfills).
4. Lapeer County Press, May 13, 1992 (Hazardous waste).
5. Lapeer County Press, July 8, 1992 (Hazardous waste).
6. Ypsilanti Press, Sept. 18, 1992 (Hazardous waste).
7. Ann Arbor News, Oct 16, 1992 (Hazardous waste).
8. Detroit Free Press, November 25, 1992 (Fire and air pollution, Mike Williams).
9. Contributor (and subject), "Case Study Course Examines Envotech's Proposed Hazardous Waste Incinerator," Findings Magazine, School of Public Health, University of Michigan, summer, 1993.
10. Air Conditioning News, Oct. 15, 1993; Oct. 25, 1993.
11. Ann Arbor News, Nov. 1, 1993 (Envotech facility and State DNR).
12. Ypsilanti Press, Nov. 30, 1993 (Superfund site cleanup).
13. Scripts News Service, Mar. 29, 1994 (Radon in drinking water).
14. Engineers Digest, Oct. 20, 1995 (Indoor air quality).
15. Flint Journal, Oct. - Nov. 1995 (Waste wood cogenerator).
16. Indoor Air Quality Update - Jan. 1996 (Indoor air quality).
17. The University Record - Dec. 1995 (Campus environmental management program).
18. Dallas Morning News - May 30, 1996 (Hazardous waste incineration).
19. Dallas Morning News/Arlington Morning News Edition - May 31, 1996 (Hazardous waste incineration).
20. Dallas Morning News - June 1, 1996 (Hazardous waste incineration).
21. Dallas/Fort Worth Star - Telegraph May 1996 (Hazardous waste incineration).
22. Cape Town South Africa Daily Argus - Jan. 1997 (AECI sulfur fire and exposure assessment).
23. Cape Town Good Hope Radio - Jan. 1997 (Sulfur fire and community health impacts).
24. Flint Journal, April 1997 (Woodwaste cogenerator).
25. Peninsula Techikon Newspaper, Bellville, South Africa - July 1997 (Air quality and environmental health).
26. Michigan Daily, Nov. 1998 (Landfill gas combustion).
27. Saginaw News, Feb. 1999 (Chemical risks, emergency plans)
28. Traverse Northern Michigan Magazine, July 16, 1999 (Incineration)
29. The Washington Post, Oct. 15, 1999 (Air pollution, environmental policy).
30. WAMC/Northeast Public Radio, Sept. 13, 2000 (NY, NH, etc.) (Health effects of air pollution)

31. Register-Star, Hudson Valley Newspapers, Sept. 14, 2000 (Health effects of air pollution).
32. WNEM-TV, CBS affiliate, Saginaw, MI, April 2000 (Indoor air cleaners and ozone).
33. Register-Star, Hudson Valley Newspapers, NY, May 22, 2001 (Health effects of air pollution).
34. The Mercury, Durban, South Africa, March 1, 2002 (‘Pollution levels linked to asthma’)
35. The Mercury, Durban, South Africa, November, 2002 (‘Air Pollution levels linked to asthma’)
36. CourtTV.com, February, 2003 (‘Indoor air quality and mold’)
37. Findings, UM School of Public Health, Fall/Winter 2003 (‘Research Steers South Africa Toward Environmental Change’)
38. Environmental Health Perspectives, Health, Environment, Economic Development Project in Durban, Jan. 2004.
39. Ann Arbor News, Ann Arbor, MI (‘Homes, Sick Homes, Perhaps’), Jan. 27, 2004.
40. East Coast Radio, Durban, South Africa (2, ‘Durban health study, International Federation of Environmental Health Meeting), Feb. 26, 2004.
41. Houston Chronicle, Houston, TX (‘Toxic Air - How we did it. Houston Chronicle's methodology in measuring and evaluating regional air quality by Dina Cappiello), March 4, 2005.
42. Houston Chronicle, Houston, TX (‘In Harm's Way. Troubled neighbors’ by Dina Cappiello), March 27, 2005.
43. Houston Chronicle, Houston, TX (‘En El Paso Del Daño - Cómo medimos y evaluamos la calidad del aire’) Miércoles 26 de enero de 2005
44. The Mercury, Durban, South Africa (‘Tackling pollution - Researchers from the University of Natal are hoping to pinpoint links between sickness and the air which people are forced to breathe’ by Tony Carnie, April 2005.
45. Civil & Environmental Engineering University of Michigan Newsletter for Alumni and Friends, Fall 2005. http://cee.engin.umich.edu/pdfFiles/Newsletter%20Fall%2005.pdf (Article on new appointments).
46. Detroit Metro Times, Detroit, MI (Environmental Impacts of the Second International Crossing in Detroit), April 17, 2006.
47. The Mercury, Durban, South Africa (Durban Health Study), Aug. 4, 2006.
48. Mail and Guardian (national paper) South Africa (Durban Health Study), Aug. 4, 2006.
49. Business Reporter, Durban, South Africa (Durban Health Study), Aug. 4, 2006.
50. Los Angeles Times, Los Angeles (Health effects of refineries), Aug. 16, 2006, Nov 5, 2006; Story includes: “Dark cloud over good works of Gates Foundation,” published Jan. 7, 2007.
51. The Dallas Morning News, “State of Neglect: Plant emissions create an air of uncertainty in Midlothian,” January 17, 2009 (Randy Lee Loftis)
52. Spinal Column Newsweekly, Polybrominated diphenyl ethers (PBDEs), January 20, 2009. http://www.spinalcolumnonline.com/publicationreturnframe.lasso?-token.address=http://www.oaklandlakefront.com
53. WDET Radio, Detroit Michigan, (EPA Study on Air Quality, Asthmatics and Roadways, 10 minute interview), July 2, 2009.
54. Free Press, Detroit, MI, July 2009.
55. University of Michigan Record Update - online, June 7, 2010, June 15, 2010
56. Edmonton.Journal.com ("Fort Saskatchewan residents sicker than neighbors: Prof") June 09, 2010
57. Edmonton Journal ("Experts criticize upgrader proposal" by Hanneke Brooymans) June 09, 2010
58. The Globe and Mail ("Delay refinery until health effects are studied, Alberta regulators urged") June 12, 2010.
59. Men's Health Journal ("Air pollution in Cars and Congestion"), May, 2011.
60. Fox 17, Grand Rapids, MI ("Flame retardants in children's items"), June, 2011.
61. WUFT Public Radio, Florida (syndicated state-wide), Public Health Minute with Bill Latimer, "Effects of Roadway Pollution," June 19, 2013.
62. MLIVE, Michigan considers loosening toxic air contaminant regulations, Oct. 14, 2013. http://www.mlive.com/business/index.ssf/2013/10/michigan_toxic_air_contaminant.html
63. University of California, Irvine. Press Release: "UCI-led study documents heavy air pollution in Canadian area with cancer spikes: Carcinogens detected in emissions downwind of ‘Industrial Heartland’", Irvine, Calif., Oct. 22, 2013.

64. University of Michigan, Ann Arbor, MI. Press Release: "U-M School of Public Health, Detroit partners aim to improve air quality in the city." Feb. 18, 2014.
65. Dirksen Senate Office Building, Senate Energy and Public Works Committee; briefing to Senators Barbara Boxer and Sheldon Whitehouse on "Human Health Impacts of Tar Sands Production and Refining," Also briefing to Senate staffers and press (3 events) Feb. 26, 2014.
66. US News and World Reports. Tar Sands Toxicity. Feb. 26, 2014.
67. The Michigan Daily, Ann Arbor, MI. Detroit study to examine effects of bad air quality. Feb. 27, 2014. P.1.
68. Al Jazeera America, New York "Detroit Air Quality, Feb. 27, 2014.
69. Environment News Service. Alberta MD: Canada 'Lying' About Tar Sands Health Impacts." Feb. 27, 2014. Ens-newswire.com/2014/02/27/alerta-md-canada-lying-about-tar-sands-health-impacts/
70. Inside Climate News, April 3, 2013. Toxic Emission Spikes at Fracking Sites Are Rarely Monitored, Study Finds. http://insideclimatenews.org/news/20140403/toxic-emission-spikes-fracking-sites-are-rarely-monitored-study-finds.
71. Scientific American. Fracking Sludge in Open Pits Goes Unmonitored As Health Worries Mount. http://www.scientificamerican.com/article/fracking-sludge-in-open-pits-goes-unmonitored-as-health-worries-mount-video/ Oct. 2, 2014.
72. InsideClimate News. Open Pits Offer Cheap Disposal for Fracking Sludge, but Health Worries Mount, https://icnbooks.creatavist.com/infrackingswake, Oct. 7, 2014.
73. Risk & Insurance Magazine: Market for Occupational Health professions. Feb. 24, 2015.
74. Algeizera TV: SO2 in Detroit. Jan. 3, 2016.
75. Portland Mercury: State Finds Alarmingly High Arsenic, Cadmium Levels Near Two SE Portland Schools. Feb. 2, 2016.
76. Kalamazoo NPR affiliate WMUK's biweekly public affairs program, WestSouthwest, History of Lead and Flint Michigan, Feb. 9, 2016.
77. The Detroit News, Flint situation, Feb. 10, 2016
78. Revolution newspaper/revcom.us (Li OneSTO), Water Crisis in Flint.
79. Newsweek, Cumulative Risk in TriCities, Feb. 11, 2016.
80. Michigan Public Radio, Issues Of The Environment: Addressing Michigan's Air Quality, April 6, 2016. http://wemu.org/post/issues-environment-addressing-michigans-air-quality
81. Newsweek, Choking To Death In Detroit: Flint Isn't Michigan's Only Disaster, March 30, 2016. http://www.newsweek.com/2016/04/08/michigan-air-pollution-poison-southwest-detroit-441914.html
82. Ann Arbor News, Expert weighs in on lead, PCB contamination at old Ypsilanti industrial site, June 8, 2016. http://www.mlive.com/news/ann-arbor/index.ssf/2016/06/public_health_expert_weighs_in.html
83. PublicSource, How one resident near fracking got the EPA to pay attention to her air quality," Dec. 15, 2017. http://publicsource.org/how-one-resident-near-fracking-got-the-epa-to-pay-attention-to-her-air-quality/
84. ALZ Forum, Pesticides Raise Risk of ALS and Potentially Alzheimer's disease, May 21, 2017. http://www.alzforum.org/news/research-news/pesticides-raise-risk-als-and-potentially-alzheimers-disease
85. The Nation. "Are We Doing All We Can to Prevent Lead Poisoning?" Feb. 21, 2017. https://www.thenation.com/article/are-we-doing-all-we-can-to-prevent-lead-poisoning/
86. Center for Public Integrity, Feb. 17, 2017. "Is your school near a busy road and its air pollution?" and "Getting under the hood: Our methodology: How we investigated schools near sources of traffic pollution nationwide" https://www.publicintegrity.org/2017/02/17/20723/your-school-near-busy-road-and-its-air-pollution and https://www.publicintegrity.org/2017/02/17/20720/getting-under-hood-our-methodology
87. Record-Eagle, Traverse City. Dry Cleaner and Water Contamination, April 11, 2017.
88. NPR Reveal: Poisoned, ignored and evicted: The perils of living with lead, Mar 31, 2018. https://www.revealnews.org/episodes/poisoned-ignored-and-evicted-the-perils-of-living-with-lead/
89. Associated Press, Partnership Develops Plan for Improving Detroit Air Quality, April 13, 2018. https://www.usnews.com/news/best-states/michigan/articles/2017-04-13/partnership-develops-plan-for-improving-detroit-air-quality

90. Bridge, "Mike Duggan blasts Abdul El-Sayed for accusing him of 'poisoning kids', April 12, 2018. https://www.bridgemi.com/public-sector/mike-duggan-blasts-abdul-el-sayed-accusing-him-poisoning-kids
91. NPR Science Desk, "Which Water Is Best For Health? Hint: Don't Discount The Tap." July 27, 2018. https://www.npr.org/sections/thesalt/2018/07/27/632393234/which-water-is-best-for-health-hint-dont-discount-the-tap
92. USGBC+ (magazine for the U.S. Green Building Council). Indoor air quality and schools. Jul7 17, 2018
93. Washington Post, (Jill Adams) "If air at home seems to bother you, try to remove the sources of irritants first," Health & Science, April 30, 2019. https://www.washingtonpost.com/national/health-science/if-air-at-home-seems-to-bother-you-try-to-remove-the-sources-of-irritants-first/2019/04/26/c37c7276-6054-11e9-9ff2-abc984dc9eec_story.html?utm_term=.eb76fdf83852
94. Baltimore Sun (Scott Dance) Researcher says Hogan administration wrongly cites study to suggest highway expansion will cut air pollution," June 5, 2019. https://www.baltimoresun.com/news/environment/bs-md-highway-pollution-20190604-story.html
95. AnnArborObserver.com, (Jena Brooker) "Living Off Campus -- Student housing can leave a lot to be desired-but few tenants know where to turn," March, 2020. https://annarborobserver.com/articles/living_off_campus.html#.Xr8jWBNKhQJ
96. Ann Arbor Observer, Schools and indoor environment. June 15, 2020.
97. Tampa Bay Times, St. Petersburg, Florida. Worker and community lead exposure from a smelter. March 12, 2020..
98. Planet Detroit, Schools and indoor environment. April 15, 2020.

Local Assistance and Advising *(selected)*

Pro bono advice to citizens, nonprofit groups, local government, industry, etc., regarding hazardous substances, soil and groundwater, and air quality, including:

1. Indoor air quality, Livingston MI, Oct. 1993.
2. Groundwater contamination from leaking underground storage tank, Oakland, MI July-Dec. 1993.
3. Potential landfill contamination, Carleton Hills, Augusta, MI, 1993-4.
4. Technical Advisory Committee, Metamora National Priority List Superfund Site, Metamora, MI, 1993-.
5. Flint Neighborhood Commission, Waste to Energy Plant, Flint MI, Dec. 1993.
6. Groundwater contamination from abandoned landfill, Ann Arbor MI, Jan. 1994.
7. Lead paint and atmospheric contamination, Ann Arbor MI, Jan. 1994.
8. Passive smoke exposure and indoor air quality, MI State Prisons, Feb., 1994.
9. Environmental equity and waste-to-energy facility, for Susan Law Center for Economic and Social Justice, March-April, 1994-6.
10. Indoor air quality, gasoline exposure, etc., in Flint, MI, 1994-5.
11. Indoor air quality, soil contamination, VOCs in Hartford IL, Illinois Dept. Public Health, Dec. 1995, April, 1996.
12. Soil contamination from landfill at school grounds; Madison Heights, Oakland County, MI, March - April, 1996.
13. Member, advisory committee, Environmental Monitoring for Public Access and Community Tracking Project, Washtenaw Country, MI, 1998.
14. Indoor air quality, University of Michigan, May, 2001.
15. Soil contamination, Beard Elementary School, Detroit, Sept. 2001.
16. Medical waste incineration, Compass Waste Incinerator Site, Groundwork, KwaZulu Natal, South Africa, Jan-April, 2006.
17. Hazard assessment for sulfur storage from oil sands facility, Bruderheim, Alberta, Canada, April 2007.
18. Landfill air quality impacts, Metropolitan Department of Health, Durban, South Africa, July 2007.
19. Gas monitoring, ChemDaq, Pittsburgh, PA, July 2011.
20. Green screen and evaluation of building materials, ICL and Bayer Corp., Pittsburgh, PA. (Dec. 2011).

CONSULTING (selected)

1. Technical Expert, Assessment of co-generation facility, Boston Housing Authority, July – August, 1985.

2. Testimony prepared for United States vs. BASF-Inmont Corp. et al., DJ90-11-3-289, concerning the Remedial Design, Remedial Action Plan, Scope of Work (SOW) and Consent Decree for the Metamora Landfill National Priorities List Site. United Citizens of Lapeer County, Metamora, MI (Sept. 1991).
3. Testimony prepared for Michigan Department of Natural Resources on proposed Carleton Farms waste management facility in Sumpter Township, MI. Citizens Environmental Association, New Boston, MI (August 1991).
4. Technical Expert and Oversight, Metamora Landfill Technical Review Committee and the Technical Assistance Grant Committee, Metamora Landfill National Priorities List Site, Metamora, MI (1994 – 1998).
5. Technical Expert and Expert Witness, Flint waste-to-energy combustion facility, Sugar Law Center, Detroit, MI (May 1995).
6. Wastewater Engineer/Public Health Specialist, US Agency for International Development, Washington DC (Egyptian assignment) (July 1995).
7. Technical Expert, review and de novo analysis of the TXI facility in Midlothian, Texas, American Lung Association of Texas (Dec. 1995-April, 1996).
8. Technical Expert, developments and applications of air filter media among compliance monitoring and other monitoring applications in Europe, Gelman Sciences, Inc. (Sept. 1996-June, 1997).
9. Expert Witness, Desai Presidential Commission of Inquiry into the sulphur fire at AECI Somerset West, Western Cape, South Africa, Jan. 29-31, 1997 (Decided May, 1998).
10. Expert Witness, NAACP vs. J. Engler, Genesee County Circuit Court, Flint, Michigan April, 1997. (Decided May 29, 1997).
11. Technical Expert, Caltex, Cape Town, South Africa (July-Aug., 1997).
12. Technical Expert, American Lung Association, Sierra Club (Aug., 1997 – April 1998)
13. Expert Witness, State Office of Administrative Hearings No 582-97-499. TNRCC Docket No. 96-1466-IHW, In the Matter of the Application of TXI Operations, L.P. For Permit No. HW-50316-00001, Dec. 1997-April, 1998.
14. Technical Expert, indoor air quality, Michigan Education Association (March-April, 1998).
15. Technical Expert, indoor air quality, Michigan Education Association (July, 1999).
16. Technical Expert, developments and applications in indoor air sampling including particulate and bioaerosols, Pall Gelman Laboratory, Inc. (August, 1999).
17. Technical Expert, water quality issues related to hydronic heating systems, Ulmer & Lambert LLP (Sept. 1999).
18. Technical Expert, life cycle analysis and environmental impacts, Ames.Alliance.com, Amesaward.com LLC (Aug. 1999, 2000, 2001, 2002, 2003)
19. Technical Expert, indoor air quality, Aircuity Inc. (Aug. 2000).
20. Technical Expert, exposure and health risk assessment, Community - St. Lawrence Cement Forum (Sept. 2000).
21. Technical Expert, indoor air quality, Collins v Damon (October – November, 2000).
22. Technical Expert, indoor air quality, Scheinfeld v Sobel (May, 2001).
23. Technical Expert, air pollution impacts, Camden (NJ) Regional Legal Services, Inc.. (Dec. 2004 - April 2005).
24. Technical Expert, medical waste incineration, World Health Organization, Geneva, Switzerland (Oct. 2003 – Jan. 2004)
25. Expert Witness. South Camden Citizens in Action v. New Jersey Department of Environmental Protection, et al. (April 2005).
26. Expert Witness. Citizens Against Pollution v. American Electric Power Co., Inc. (Jan. 2005 - Sept. 2006).
27. Technical Expert. medical waste incineration and infection control, Mozambique JHPIEGO/Johns Hopkins University and Centers for Disease Control, (Nov. 2006 –July, 2007; October 2008 – March 2009, Feb. 2010-Dec. 2010, July-Aug. 2011).
28. Technical Expert. Air quality impacts (Jan. 2008-April 2008).
29. Technical Expert. Indoor air quality, Environment Canada (Nov. 2008 - 2010)
30. Expert Witness. Sulfur storage and risk assessment, Natural Resources Conservation Board, Friends of Lamont County, Alberta, Canada (Jan. 2009 – April 2009).
31. Expert Witness. Upgrader/refinery exposure, health risk assessment, Natural Resources Conservation Board, Alberta, Canada (Jan. 2010 – June 2010).

32. Expert Witness. Sour gas well and pipeline exposure and risk assessment, Energy Resources and Conservation Board, Alberta, Canada (Sept. 2010 – Dec. 2010).
33. Technical Expert. Medical waste incineration and infection control, Rwanda, JHPIEGO/Johns Hopkins University and Centers for Disease Control (Aug. 2011, March - July 2013).
34. Technical Expert/Expert Witness. Gravity assisted oils sands extraction, Energy Resources and Conservation Board, Alberta, Canada (July - Dec. 2011).
35. Technical Expert. Exposure, toxicology and risks of hydrogen sulfide. Sierra Club, Washington DC (Dec. 2011 – Aug. 2012).
36. Technical Expert. Indoor environmental quality, Coyne Public Relations (Feb. 2012)
37. Technical Expert. Hydrocarbon/vapor nuisance, Manistee, Michigan (Oct. 2012).
38. Technical Expert/Expert Witness. Simon Properties Group et al. v. Aon Risk Services Central, Inc., Health risk assessment (Feb. 2012 -).
39. Technical Expert. Methanol emissions and impacts on mold and health (March. 2013)
40. Consultant. The House Dust Fungal Microbiome – Influences and Effects, Sloan Foundation Grant, Susan Lynch, PI, University of Southern California. (Oct. 2013-)
41. Technical Expert. Petroleum coke storage and health impacts. National Resource Defense Council. Sept. 2013 - March, 2014.
42. Technical Expert. Kinder Morgan TransMountain Expansion Pipeline application, Living Oceans Society. Jan. – May, 2014.
43. Technical Expert, Emissions and exposures. Sierra Club v. Union Electric Company d/b/a/ Ameren Missouri, Civil Action No. 14-cv-00408-AGF (2016)
44. Technical Expert. Lead service line sampling and analysis, and health risks. City of Chicago. Tatjana Blotkevic, Ilya Peysin and Yakov Yarmove v. City of Chicago, No. 2016-CH-02292, March 2016 to present..
45. Technical Expert. Fire related exposures and health impacts. Robert and Kerry Ellen Hart vs. Mountain West Farm Bureau Mutual Insurance Company; U.S. District Court Cause No. CV 19-08-M-DWM. Feb., 2019 – Feb. 2020.

RESEARCH AND TRAINING FUNDING HISTORY

Awarded Research Grants and Contracts: External

1. Synthetic Fuels Corporation, Ambient Monitoring near Synfuel Plants, S. Batterman (Consultant), $50,000 (total costs), 6/20/84 - 6/19/85.
2. Environmental Protection Agency, Assessment of Air Quality Models and Their Applications, S. Batterman (Consultant) $300,000 (total costs), 9/20/84 - 9/20/86.
3. Nordic Council of Ministers, Natl. Environment Protection Board, Solna, Sweden, Cost-Effectiveness Analysis of Emission Control Policies in Europe, S. Batterman (CoInv), 150,000 D. Krone (total costs), 7/1/87 - 8/26/87.
4. McDonald Douglas Astronautics Co., Assessment of Fate of Particles and Gases Released from a Manned Space Station, S. Batterman (CoInv), $60,000 (total costs), 3/1/87 - 12/31/88.
5. Texas Water Resources Institute, Water Demand Management Using Real-Time Automatic Decentralized Control, S. Batterman (PI), $15,000 (direct costs), 3/3/87 - 12/31/88.
6. Houston Area Research Council, Evaluating In Situ Treatment Processes for Hazardous Waste, S. Batterman (PI), $12,000 (direct costs of computer access grant), 6/2/87 - 12/31/88.
7. Environmental Protection Agency, Variability of Soil and Street Dust in the Philadelphia Area, S. Batterman (PI), $1,000 (direct costs), 9/1/87 - 12/31/87.
8. Gulf Coast Hazardous Substances Research Center, Soil/Air Fluxes of Hazardous Substances at Treatment, Storage and Disposal Facilities: Models and Measurements, S. Batterman (PI), $50,000 (direct costs), 2/1/88 - 8/30/90.
9. NSF, "Modeling and Estimation of Contaminant Soil/Air Fluxes," S. Batterman (PI), $59,923 (total costs), 6/30/88 - 6/30/90.
10. Advanced Technology Program, Texas Coordinating Board, Synthesis of Hydraulic and Pneumatic Controls for Hazardous Site Remediation, S. Batterman (PI), $383,000 (direct costs), 6/1/88 - 9/1/89.
11. Advanced Technology Program: Texas Coordinating Board, Hazardous Airborne Contaminants: Sampling, Assessment and Control, S. Batterman (PI), $130,010 (direct costs), 6/1/88 - 9/1/89.

12. US EPA, Soil/Air Fluxes of Hazardous Substances at Treatment, Storage and Disposal Facilities: Models and Treatment, S. Batterman (PI), $59,975 (total costs), 5/30/89 - 6/1/90.
13. US EPA, Transport of Organic Contaminants in Soils: Vapor Sorption/Desorption Processes, S. Batterman (PI), $35,000 (total costs), 1/1/90 - 3/31/90.
14. US EPA, Soil/Air Fluxes of Hazardous Substances at Treatment, Storage and Disposal Facilities: Models and Treatment, S. Batterman (PI), $62,017 (total costs), 3/1/90 - 11/31/91.
15. Johnson's Corp., Investigation of Fungal Volatiles, S. Batterman (CoInv), $30,000 (total costs), 9/1/90 - 9/1/92.
16. US Department of Energy, Assessment of Subsurface VOCs Using a Chemical Microsensor Array, S. Batterman (PI), $223,351 (total costs), 10/1/90 - 6/31/92.
17. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Pollution Sources in Heating, Ventilating, and Air-conditioning (HVAC) Systems: Phase 1. Identification and Quantification of Sources, S. Batterman (PI), $173,053 (total costs), 9/1/92 - 5/31/95.
18. US Department of Energy, Measurements of Vadose Zone Transport Properties, S. Batterman (PI), $95,964 (total costs), 2/1/93 - 1/30/95.
19. NIOSH, "Biological Monitoring of Methanol Exposures," $432,000 (total costs), S. Batterman (CoInv), 1/1/93 - 6/31/95.
20. Department of Agriculture, National Particle Board Association, Emission of VOCs from Wood Composites, S. Batterman (PI), $32,500 (direct), 3/15/94 - 12/31/95.
21. US EPA, "Biodegradation, Kinetics, Oxygen Transfer and Bioavailability in Bioventing and Related Technologies," S. Batterman (CoInv), $300,000 (direct costs), 5/1/94 - 4/30/95.
22. Gelman Sciences, Investigation of Air Filter Characteristics, $18,000, S. Batterman (PI), 9/1/95-6/1/96.
23. Finnish Academy of Sciences, Support for Visiting Professorship, $20,000, S. Batterman (PI), 6/1/96-12/31/96.
24. US EPA, Evaluation of the Efficacy of a New Secondary Disinfectant Formulation Using Hydrogen Peroxide and Silver and the Formulation of Disinfection By-Products Resulting From Interactions With Conventional Disinfectants, S. Batterman (PI), $594,346 total, $470,708 direct, 5/1/97 - 5/30/01.
25. US EPA, "Longitudinal Studies of Indoor Air Quality in Office Buildings," $430,000, S. Batterman (PI), 6/1/97 - 5/30/01.
26. Michigan Small Business Research Program, Continuous Monitoring of Volatile Organic Compounds (VOCs) Affecting Indoor Air Quality in Laboratory and Industrial Environments, S. Batterman (Co-Inv), $100,000 ($15,000 subcontract to UM), 8/12/96 - 5/12/97. Grant No. 801P6001063.
27. Fogarty Foundation/US Dept. Of Health and Human Services, International Training and Research in Environmental and Occupational Health, T. Robins (PI), S. Batterman (consultant), 9/1/96-8/31/01, $865,000.
28. NSF, Use of High Speed Gas Chromatography to Monitor Microbial VOCs, S. Batterman (Co-Inv), $75,000, ($27,000 subcontract to UM), 2/15/97-9/15/97.
29. Foundation for Research Development (Pretoria, South Africa), Cape Air Quality Project, E. Cairncross (PI), S. Batterman (Team member), R42,000 (US ~$10,000) 1/1/97-1/1/98.
30. Center for Indoor Air Research (Batterman), Gas Phase Filtration for VOC and Oxidant Removal: Laboratory and Field Assessment, S. Batterman (PI), 8%, $381,985, 9/1/99 - 8/30/01.
31. US Agency for International Development, Faculty, Curriculum and Research Development Related to Cleaner Production Technologies and Advanced and Smart Materials: A Tertiary Education Linkage Project Between The University of Michigan and The Peninsula Technikon, S. Batterman (PI), South Africa, 8%, $460,000, 6/1/99 – 5/30/03.
32. MyIndoorAir, Inc. Analysis and Presentation of IAQ Monitoring Data, S. Batterman (PI), $2,500, 9/1/00-5/1/01.
33. Precision Air, Indoor Air Quality in the Work Environment, S. Batterman (PI), $10,290, 12/1/00 – 12/31/01.
34. Durban Metro Council (South Africa), "Air Contaminant Exposures, Acute Symptoms and Disease Aggravation Among Learners and Teachers at The Settlers School in South Durban," T. Robins (PI), S. Batterman (Co-PI), 200,000 R (approximately $30,000) plus numerous in-kind contributions, 2/1/2001 – 12/31/01.
35. NIOSH RO1, "Microanalytical system for indoor VOC monitoring, E. Zellers (PI), S. Batterman (Co-Inv), $782,546 (total), $550,000 (direct), 4/1/02 – 3/31/05.

36. NSF, Sustainable Infrastructure Materials and Systems: Integration of microstructure tailoring and life cycle analysis of engineered cementitious composites (ECC). G Keolian (PI), S. Batterman (Co-Inv). $106,000 (NSF), $156,036 (total), 9/1/02 – 8/31/03.
37. CDC, "Ambient Air Pollution and Adverse Birth Outcomes: A Linked Analysis: Linking Chronic Disease and Environmental Data Sources," R.Wahl (PI), Batterman directs UM subcontract, 10/1/02 – 9/30/05, $165,000 (approximately)
38. NIOSH, "Indoor Air Quality in Public Schools: An Assessment of Exposures and Symptoms of Teachers", S. Batterman (PI), A. Franzblau (Co-PI), $33,000 (direct), 12/1/02 – 6/30/03.
39. American Chemistry Council "Understanding Exposure to Volatile Organic Air Toxics", S. Batterman (PI), $899,385, 6/1/03 – 5/30/06.
40. NSF, Sustainable Infrastucture Materials and Systems: Integration of Microstructure Tailoring and Life Cycle Analysis of Engineered Cementitious Composites, G. Keoliean (PI), S. Batterman (Co-Inv). $2,000,000, 9/1/03 – 8/30/08.
41. NIH R21, "Health, Pollution & Economic Development in South Durban," S. Batterman (PI), $266,083 total, 7/1/03 – 6/30/05.
42. Durban Metro Council, "The Health Status And Risk Factors Associated With Adverse Health Outcomes Among The Durban South Community Durban Metro, South Africa," R. Naidoo (PI), S. Batterman (Co-PI) 6/1/03 – 5/30-05, $800,000 (direct).
43. US EPA (Mickey Leland National Urban Air Toxics Research Center), "Impact of Exposure to Urban Air Toxics on Asthma Utilization for the Pediatric Medicaid Population in Dearborn, Michigan," B. Wahl (PI of Michigan Department of Community Health portion), S. Batterman (PI – Michigan portion), 1/1/05-12/31/06, $200,000.
44. US EPA (Great Lakes National Program Office), "Emissions of PBDEs from Urban Sources in the Great Lakes Region," S. Batterman (PI), 10/1/05 – 9/30/07, $79,988.
45. US EPA (STAR), "Emissions of Brominated Flame Retardants (BFRs) from Industrial and Commercial Sources in the Great Lakes Region," S. Batterman (PI), 5/1/06-5/31/08, $117,685.
46. US Civilian Research and Development Foundation, "Sources, Transport and Impacts of PBDEs In The Russian Arctic," S. Batterman (PI), $49,150, 5/1/06 – 9/30/08
47. US EPA (Mickey Leland National Urban Air Toxics Research Center), "Distribution and Determinants of VOCs", S. Batterman (PI), 11/1/06-10/30/07, $50,000.
48. NIEHS RO1, "A Community Based Participatory Research Intervention for Childhood Asthma Using Air Filters and Air Conditioners," E. Parker (PI), S. Batterman (Co-Inv), 7/1/07-6/30/12, $2,000,000 (direct).
49. NIEHS RO1, "Role of Diesel and Other Vehicular Exhaust in Exacerbation of Childhood Asthma," T. Robins (PI), S. Batterman (Co-Inv), 9/1/07-8/30/12, $2,900,000 (direct).
50. US EPA (STAR) The Detroit Asthma Morbidity, Air Quality and Traffic (DAMAT) Study, B. Wahl (PI), S. Batterman (PI UM Portion), 9/1/07-8/31/10, $750,000.
51. NIEHS RO1, "Mechanisms of Inflammation in Gestational Membranes, 7/1/08 – 6/30/13, R. Loch-Carruso (PI), S. Batterman (Co-Inv), $1,500,000.
52. US EPA Cooperative Agreement, "Childhood Health Effects from Roadway and Urban Pollutant Burden Study" Health Effects of Near-Roadway Exposures to Air Pollution, EPA-G2008-STAR-B1, S. Batterman (PI), 10/1/08-9/31/11, $1,400,000 plus EPA in-kind contribution plus $70,000 supplement.
53. Health Canada, "Critical review of the sources and exposure levels of benzene, toluene, xylene and naphthalene relevant to Canadian residential indoor environments," S. Batterman (PI), 11/1/08-5/30/09, $25,000.
54. HEI, "Modeling and analysis of personal exposure to pollutant mixtures: Further analysis of the RIOPA data," Health Effects Institute. 2009-2011. S. Batterman, PI, 2010-2012. $162,000.
55. NIEHS RO1, "Interactions of Diesel Exhaust and Respiratory Viruses on Asthmatic Children," T. Lewis, PI, S. Batterman (Co-Inv), 2010-2015. $3,200,000 (total).
56. US EPA, "Nitro-PAHs & diesel exhaust toxins in the Great Lakes. Great Lakes Restoration Initiative, S. Batterman, PI, 2010-2012. $288,828.
57. NIEHS P30, "Core Center in Environmental Health - Lifestage Exposures and Adult Disease", H. Hu (PI), S. Batterman (Co-Inv). 7/1/11 – 6/30/15, $2,400,000 (direct).

58. FCT, "Indoor Environment and Health Related Quality of Life in Elderly Assisted Living Residences," A. Mendes (PI) Financiamento do Fundo Social Europeu e de fundos nacionais do MCTES. Grant from FCT to University of Porto (Portugal), including field work, 6 months of study at University of Michigan for a doctoral student.
59. Fulbright Scholar Award, In Public/Global Health at the University of Coimbra, Coimbra, Portugal. April 2011.
60. HEI, "Enhancing Models and Measurements of Traffic-Related Air Pollutants for Health Studies using Bayesian Melding" Health Effects Institute. 2014-16. S. Batterman, PI, $650,177.
61. R01 NIEHS, "Community Action to Promote Healthy Environments". Batterman, Schultz (Co-PIs), 1/1/14 – 12/31/19, $2,300,000 (direct).
62. STAR, US EPA, "Environmental Quality, Health and Learning in Conventional and High Performance School Buildings," S. Batterman (PI), 10/1/14 - 12/31/17, $1,000,000
63. 1-U2C-ES-026553-01, Michigan Children's Health Exposure Analysis Resource Laboratory, Meeker, PI, 9/30/15-8/31/19, $9,500,000.
64. GEOHUB, NIOSH, DOS, The West Africa-Michigan CHARTER II for GEOHealth-USA, Robins, PI, 09/28/15-08/31/20, $1,800,000.
65. F32 NIH NIEHS, Spatio-temporal models of allergenic pollen for human exposure and health investigations, Katz (PI), Batterman, mentor, 01/01/16-12/31/19, $160,000.
66. P30E NIH NIEHS, The University of Michigan Core Center in Environmental Health ("Lifestage Exposures and Disease. Loch-Caruso, PI. Batterman, Exposure Core lead. 04/01/16-03/31/21, $7,500,000.
67. F32 NIH NIEHS, Spatio-temporal models of allergenic pollen for human exposure and health investigations, Batterman (PI), 01/01/16-12.31.19, $160,000.
68. R01-ES-026578-01 (Park) NIH/NIEHS, Exposure to multipollutants and obesity, type-2 diabetes and metabolic syndrome, Park (PI), 8/1/16-4/30/21, $2,446,324
69. R01-ES026964 NIH/NIEHS, A Longitudinal Study of Endocrine Disruptor Mixtures and Reproductive Aging, Park (PI), 8/1/16-7/31/21, $2,442,826 (direct)
70. R01-ES030049-01A1 NIH/NIEHS, Mapping the ALS Exposome to Gain New Insights into Disease, 1/1/2020 - 10/31/2024, Batterman/Feldman (Co MPI)
71. Fulbright US Scholar Award, 9/1/20 to Portugal and AIRS Centre.
72. City of Detroit/State of Michigan (Batterman) Air Monitoring for the Gordie Howe International Bridge, 06/01/2018-06/14/2020, $413,000

Awarded Training Grants and Scholarships: External

73. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Award, S. Batterman (PI), $181,000 recommended for 2/1/93 - 6/30/95, $42,000 awarded for 2/93 – 6/30/94.
74. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $58,940, 6/30/94 – 7/1/95.
75. Air and Waste Management Association Scholarship Award for Jonathan Greene, Nov. 1994, $1,500.
76. American Society of Heating, Refrigeration and Ventilation Engineering Scholarship Award for Marianna Luoma, March, 1995, $1,500.
77. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $60,156, 6/30/95 – 7/1/96.
78. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $60,904, 6/30/96- 7/1/97.
79. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Four-year Competitive Renewal, S. Batterman (PI), $271,000 recommended for 6/30/97 - 7/1/2001, $58,904 awarded for 6/30/97- 7/1/98.
80. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $61,000 (total costs), 6/30/98- 7/1/99.
81. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $57,200 (total costs), 6/30/99- 7/1/00.

82. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $59,434 (total costs), 6/30/00- 7/1/01.
83. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $493,693 recommended for 6/30/01-7/1/05, $76,500 awarded for 6/30/01-7/1/02.
84. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/02-7/1/03.
85. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/03-7/1/04.
86. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Annual Renewal, S. Batterman (PI), $78,000 (total costs), 6/30/04-7/1/05.
87. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $450,000 recommended for 6/30/05-7/1/08, $72,500 awarded for 6/30/05-7/1/06.
88. National Institute for Occupational Safety and Health, Hazardous Substance Academic Training Program in Educational Resource Centers, Competitive Renewal, S. Batterman (PI), $450,000 recommended for 6/30/05-7/1/08, $72,500 awarded for 6/30/05-7/1/06.
89. Michigan Education Resource Center, National Institute for Occupational Safety and Health, Pilot Project, Post-doctoral training for S. Charles, S. Batterman (PI), $20,000 6/30/06- 7/1/07.
90. Michigan Education Resource Center, National Institute for Occupational Safety and Health, Pilot Project, Post-doctoral training for Jo-Yu Chin,
91. S. Batterman (PI), $20,000 6/30/08- 7/1/09. Michigan Education Resource Center, National Institute for Occupational Safety and Health, Pilot Project, Post-doctoral training for Feng Su, S. Batterman (PI), $20,000 6/30/09- 7/1/10.
92. S. Batterman (PI), $1,640,000 6/30/10- 7/1/11. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.
93. S. Batterman (PI), $1,640,000 6/30/11- 7/1/12. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.
94. S. Batterman (PI), $1,640,000 6/30/12- 7/1/13. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.
95. S. Batterman (PI), $1,540,000 6/30/13- 7/1/14. Michigan Center for Occupational Health and Safety Engineering Education Resource Center, National Institute for Occupational Safety and Health.
96. Michigan Bloodspot Environmental Epidemiology Project, Program Round 1, "“Investigation and assessment of the use of blood spots for retrospective exposure estimation of persistent organic contaminants, including chlorinated and brominated compounds, in human blood.” S. Batterman, PI, $25,000, 2013-4.
97. Michigan Bloodspot Environmental Epidemiology Project, Program Round 2, “Advanced Methods for Analysis of Persistent Organic Pollutants in Dried Blood Spots.” S. Batterman, PI, $25,000, 2014-5.
98. NIOSH Educational and Research Center, Dried Blood Spot (DBS) Sampling for Biomonitoring in Occupational Settings.” S. Batterman, PI, $20,000, 7/12/14 – 6/30/15.
99. NIOSH Educational and Research Center, VOC Exposure in Nail Salons.” Pilot Project Post-Doctoral Training for Lexuan Zhong. S. Batterman, PI, $28,000, 7/1/16 – 6/30/16.
100. NIOSH Educational and Research Center, Occupational Inhalation Exposure To And Health Risk Of Volatile Organic Compounds Of Hotel Housekeepers” Pilot Project Post-Doctoral Training for Nan Lin, S. Batterman, PI, $28,000, 7/1/18 – 6/30/19.
101. S. Batterman, NIEHS T32ES007062-34 Environmental Toxicology and Epidemiology Pre/Post Doctoral Research Training, 7/01/2015-06/30/2020 $1,800,000 (direct)

Awarded Grants and Contracts: Internal (all direct costs):

102. Research Incentive Fund, Texas A&M University, Professional Development in Hazardous and Solid Waste Modeling and Assessment, S. Batterman (PI), $2,340 (direct costs), 6/11/87.

103. Excellence Program, Texas A&M University, Intermedia Transport and Fate of Hazardous Substances, S. Batterman (PI), $67,000, 3/1/87 - 3/1/88.
104. Center for Teaching Excellence, Texas A&M University, Incentive Grant: Case Study of Hazardous Waste Facility Siting, S. Batterman (PI), $1,000, 4/15/87.
105. International Enhancement Grants Program, Texas A&M University, Analysis of Optimal Emission Abatement Strategies, S. Batterman (PI), $700, 9/22/87.
106. Department of Civil Engineering, Texas A&M University, Funds for Gas Chromatograph/Mass Spectrometer, S. Batterman (PI), $2,500, 10/31/88.
107. School of Public Health, University of Michigan, Laboratory Equipment Funds, S. Batterman (PI), $78,000, 9/1/89.
108. Interdisciplinary Grant Program, Office of Vice President for Research, University of Michigan, Deposition and Flux Measurements of Hydrocarbons Using Fast Response Analyzers, S. Batterman (PI), $30,000, 11/1/89 - 5/1/90.
109. School of Public Health, University of Michigan, Repair Funds for Gas Chromatograph/Mass Spectrometer, S. Batterman (PI), $8,000, 12/2/91.
110. Rackham Faculty Grant, University of Michigan, Assessment and Apportionment of Urban Toxics, S. Batterman (PI), $9,968, 5/1/92 - 4/30/95.
111. International Institute, University of Michigan, Fund for Conferences And Workshops, Workshop and Course on Air Quality Modeling, Monitoring and Control in South Africa, S. Batterman (PI), $1,850, 6/1/97-8/1/97.
112. Rackham Distinguished Faculty and Graduate Student Seminar Program, University of Michigan, Environmental Justice - Law and Science, S. Batterman (PI), $7,500, 4/25/97-5/17/99.
113. Office of the Vice President for Research and Development, University of Michigan, “Core Research Facilities and Equipment Grant,” S. Batterman (PI), $100,000, 9/10/98.
114. University of Michigan Office of the Vice President for Research, “Water Disinfection By-products in Breast Milk of Nursing Mothers,” A. Franzblau (PI), S. Batterman (Co-PI), 5/1/02 – 4/30/03. $18,444.
115. University of Michigan Office of the Vice President for Research, “Distribution and Effects of Emerging Contaminants on Great Lakes Ecosystem Health,” S. Batterman (PI), 9/1/04 – 8/30/05. $56,183.
116. University of Michigan Tobacco Research Network, “Post Doctoral Training in Exposure Assessment & Environmental Health: Quantifying and Reducing Exposures to Environmental Tobacco Smoke,” 9/1/05 – 8/30/07, $79,919.
117. Graham Environmental Sustainability Institute, “Sustainable Control of Water-Associated Diseases – A Systems Approach,” S. Batterman, PI, $5,000, 2/1/08-12/31/08.
118. Graham Environmental Sustainability Institute, “Climate-induced shifts in distributions and environmental health risks of pesticides and other persistent organic pollutants in Arctic ecosystems,” S. Batterman, PI, $20,000. 1/1/11 – 12/31/11.
119. Graham Environmental Sustainability Institute, "Regional, Spatial and Temporal Mapping of Air Pollution In Detroit", S. Batterman, PI, $40,000, 4/1/11-3/31/13.
120. University of Michigan, M-Cubed Project. "Environment and Epigenetics in ALS." Feldman (PI), B. Callaghan (Co-Inv), S. Batterman (Co-Inv), $50,000, 6/1/13-5/30/14.
121. University of Michigan, Presidents Call to Action on the Flint Water Crisis. "Development of Water Safety Plan." G. Daigger (PI), S. Batterman (Co-Inv), $60,000, 9/1/15-12/31/16.